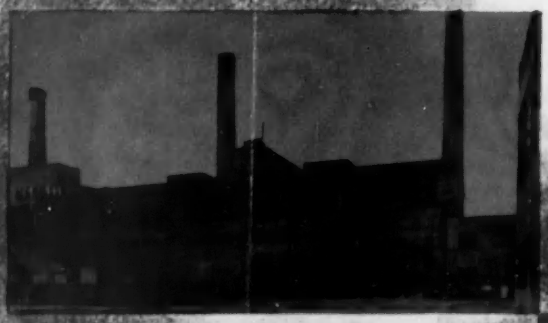
4 AUGUST 1955 ONE SHILLING

ELECTRICAL TIMES



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Messrs. Merz and McLellan

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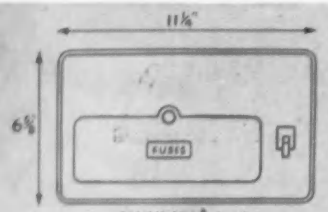
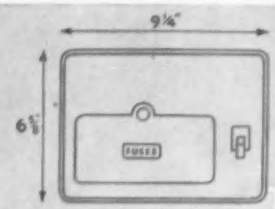
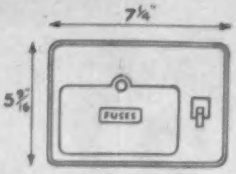


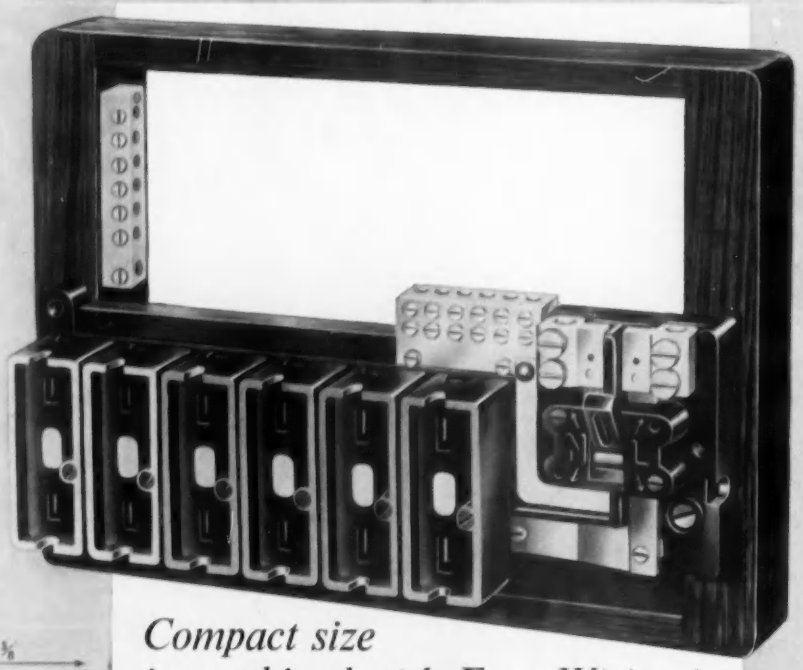
8 WAY All-Insulated
3 1/16" projection



6 WAY All-Insulated
3⅝" projection



4 WAY All-Insulated
3 1/16" projection



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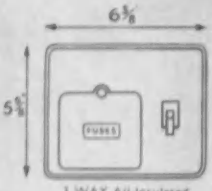
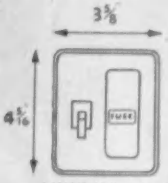
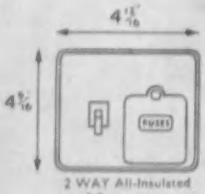


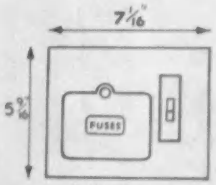
3 WAY All-Insulated
3 3/32" projection



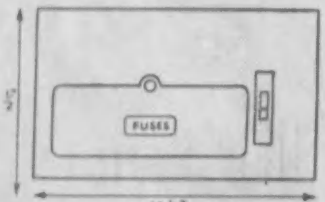
1 WAY All-Insulated
2 5/16" projection



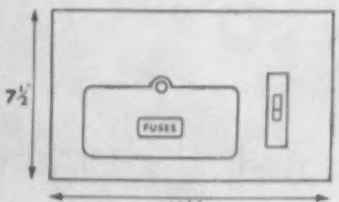
2 WAY All-Insulated
2 5/16" projection



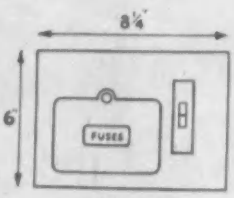
3 WAY Metalclad
3⅝" projection



8 WAY Metalclad 3 5/16" projection

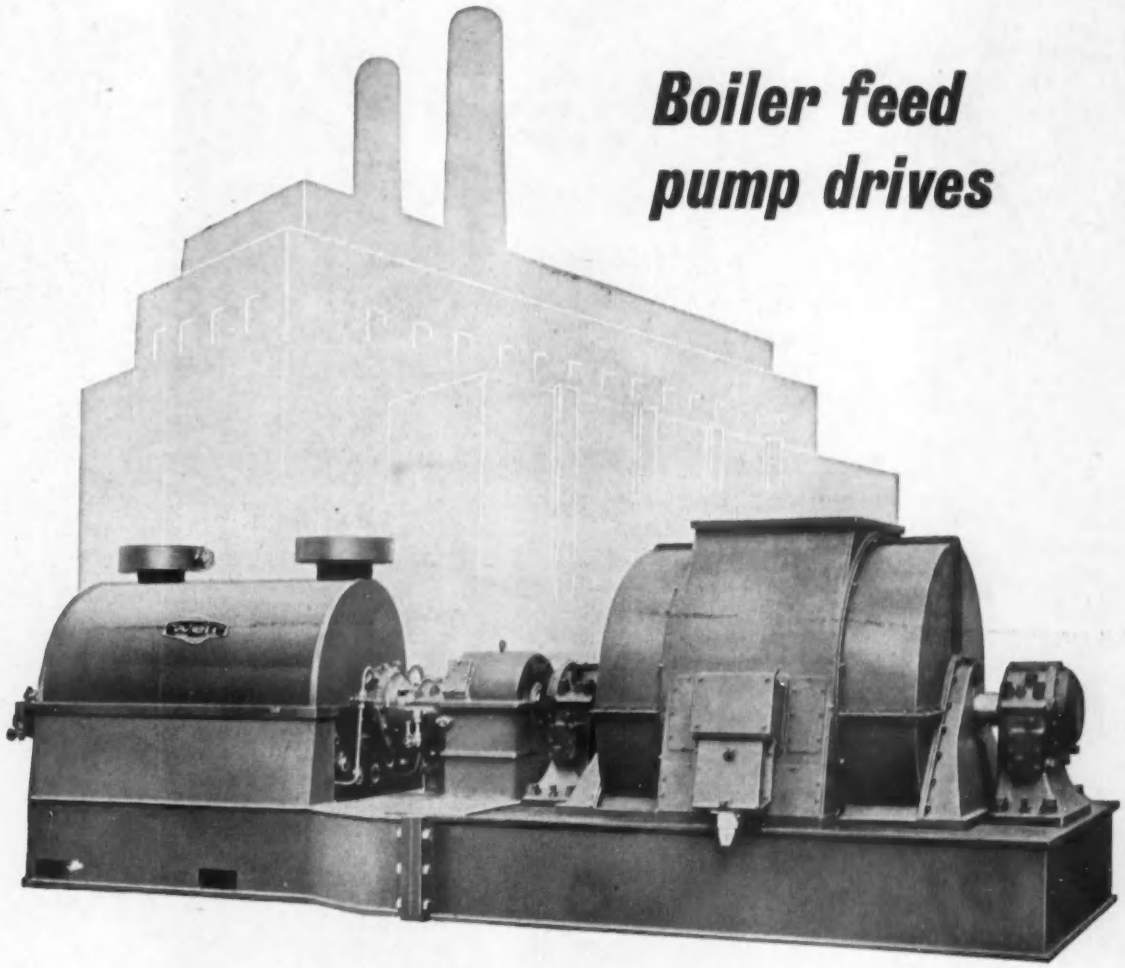


6 WAY Metalclad 3 5/16" projection



4 WAY Metalclad
3 5/16" projection

Boiler feed pump drives



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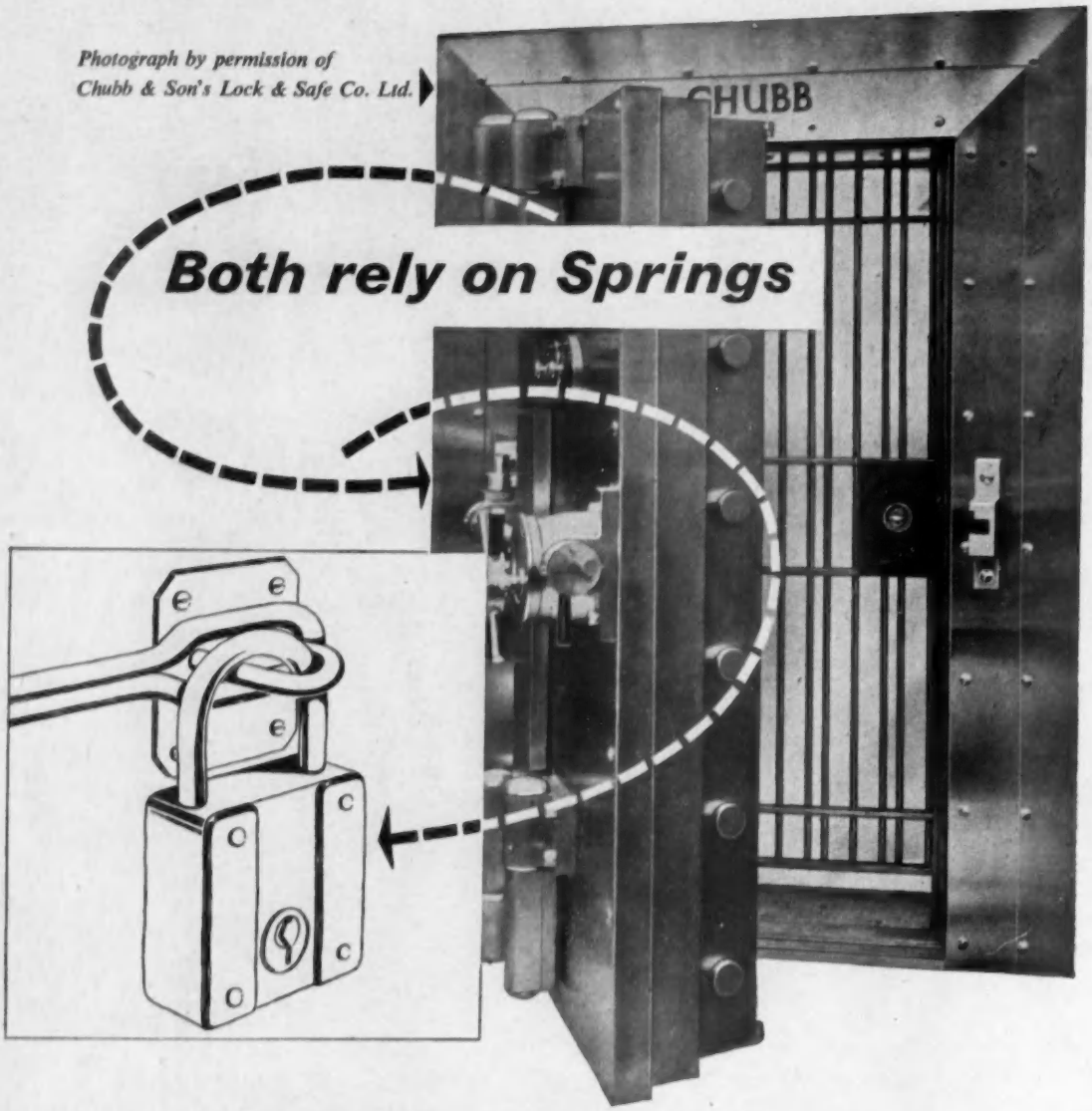

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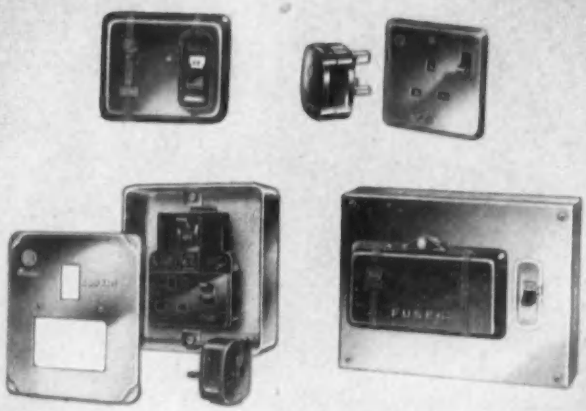

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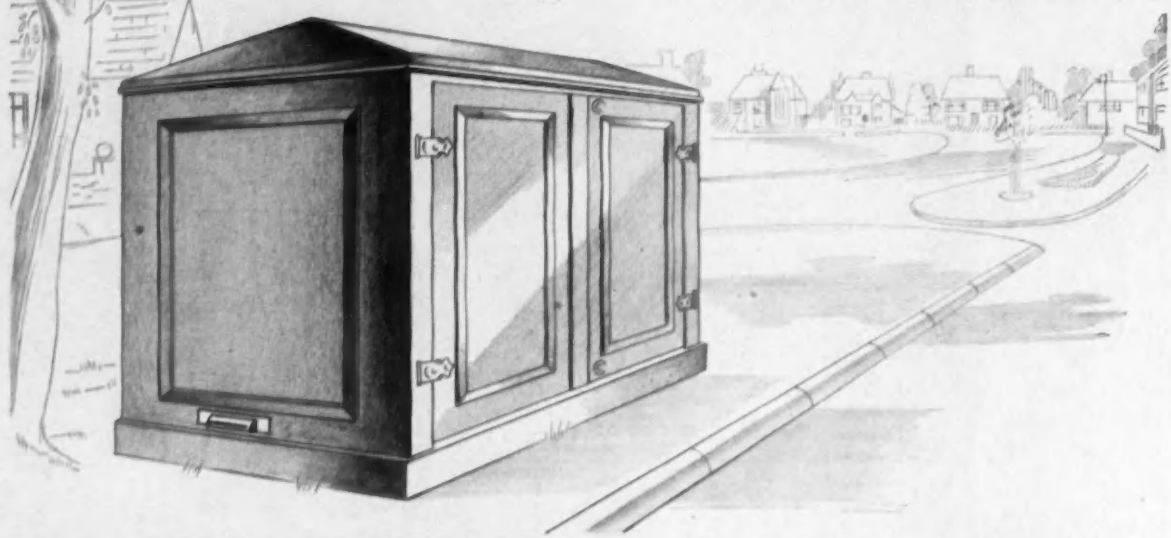

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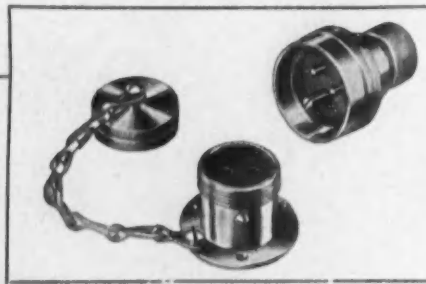

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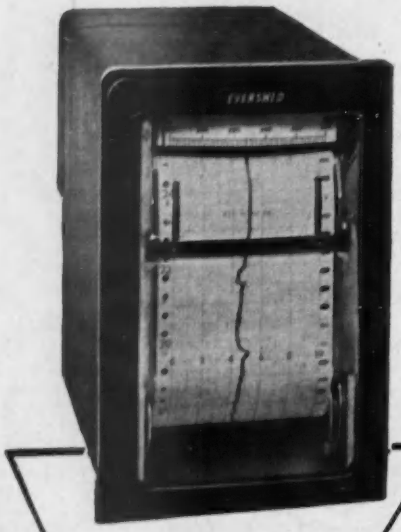

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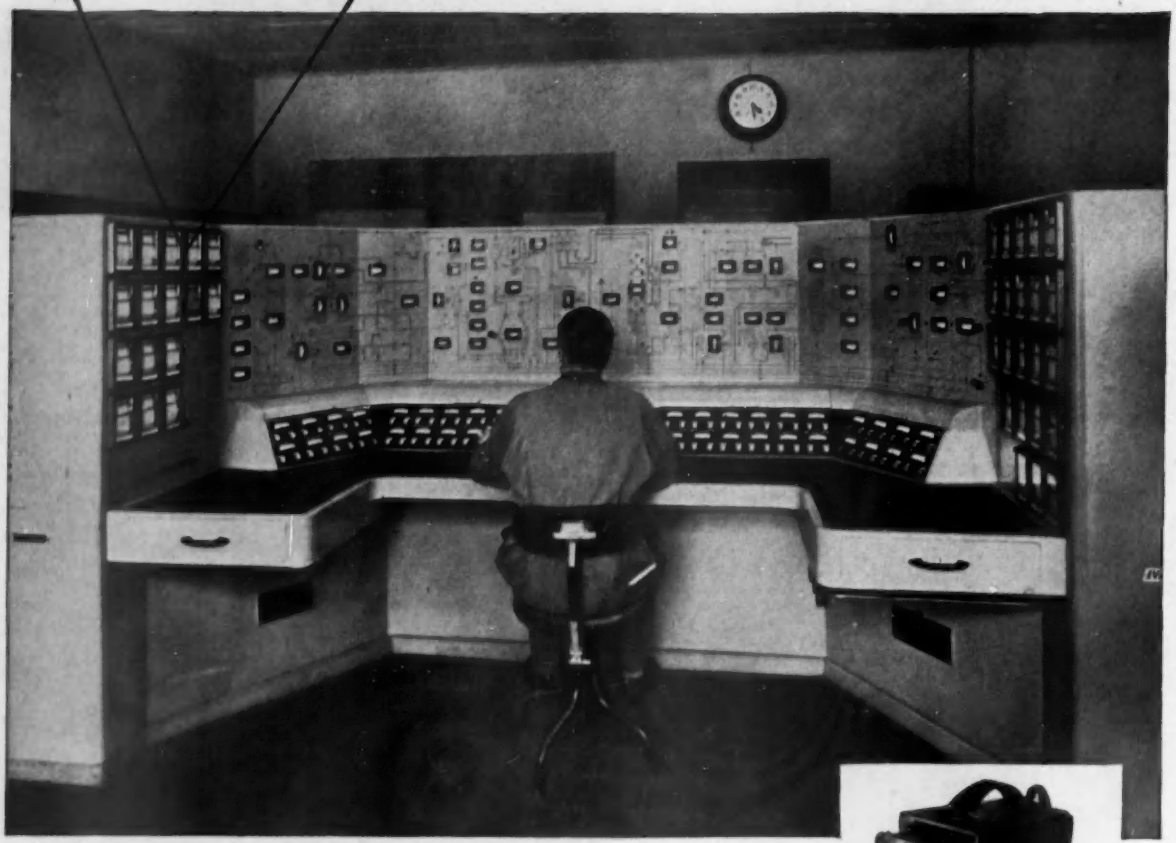

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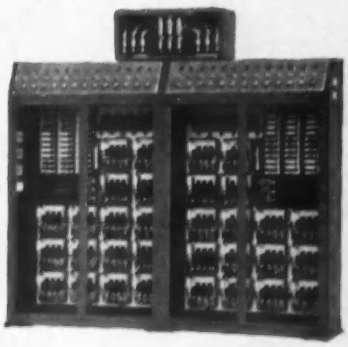

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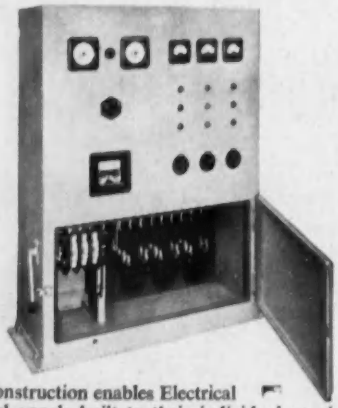

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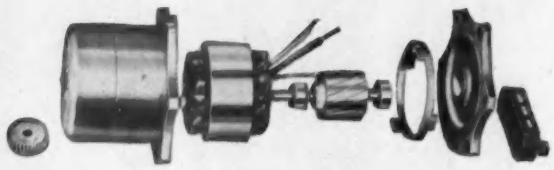

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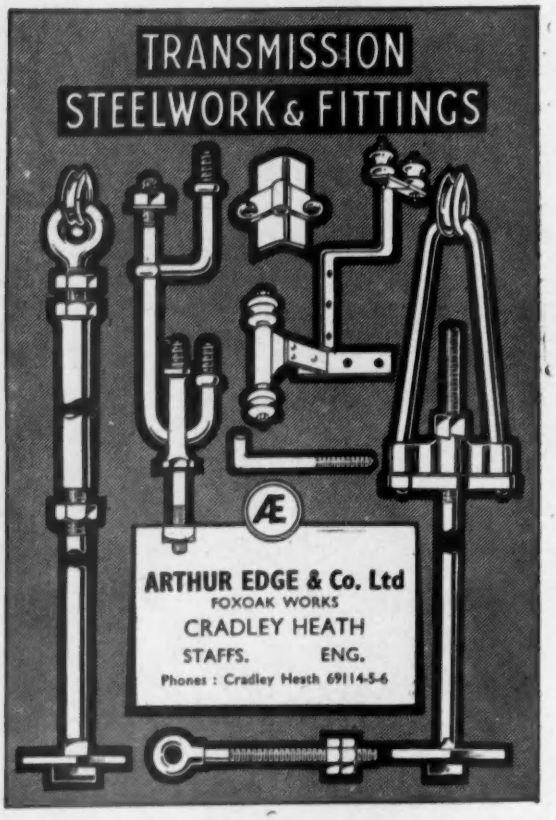

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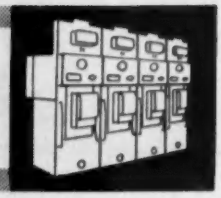

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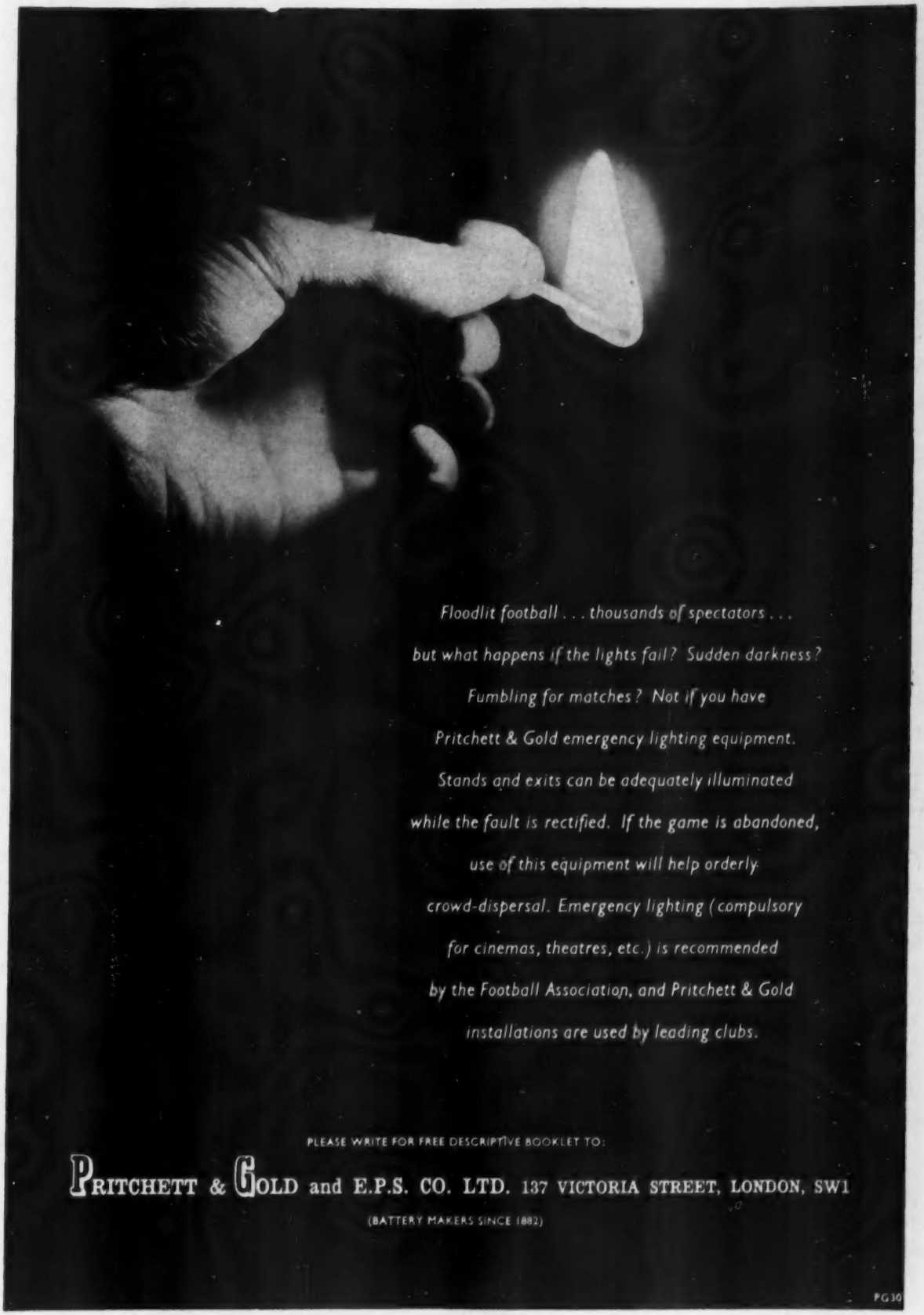
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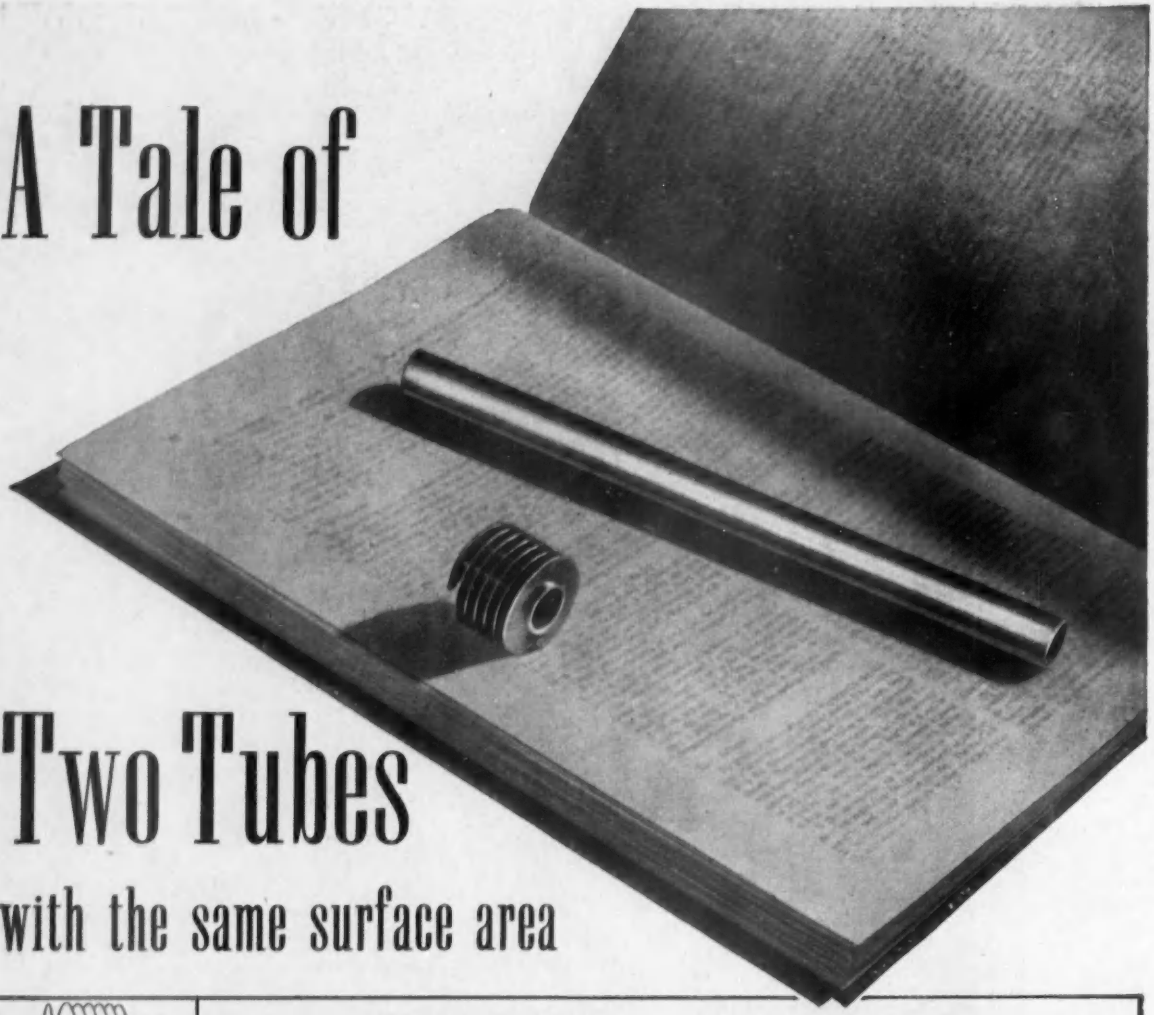

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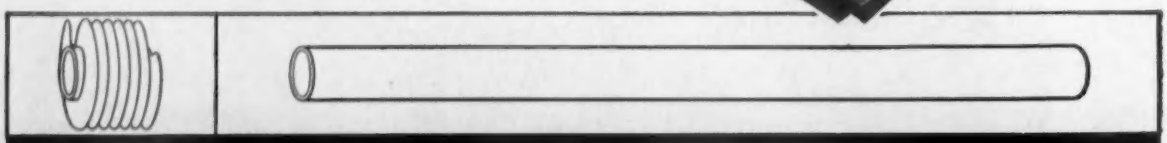
with the same surface area



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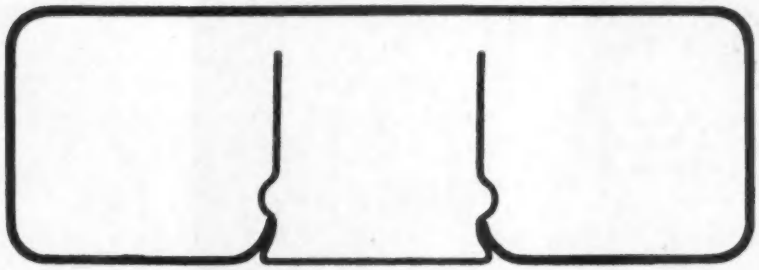

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Leading Contractors enthusiastically endorse the superiority of the new Ediswan shallow lighting trunking. In addition to the facilities commonly offered by trunking systems it has several unique features including an unobtrusive appearance which allows its use in decorated interiors. And the cost is low.

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For all standard Lighting Fittings. Ediswan trunking is robust, easy to handle and to install. It consists of 4½″ wide by 1½″ deep 18 swg. "Bonderised" and enamelled steel channel in 13ft. lengths. These are coupled together by junction pieces to form a continuous run along which any standard type of lighting fittings (tungsten, fluorescent or mercury discharge) can be positioned as required. Snap-in cover strips are used to seal the trunking between fittings.

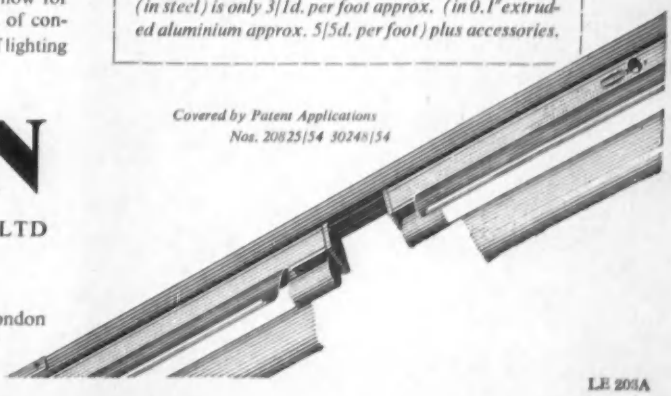
For the support of the lighting fittings there is a carrier plate of unique design, which is secured in any desired position by two bonding screws (these also ensure the low resistance earthing essential for instant start circuits), providing female entry for ¾″ conduit.

For other power operated equipment. Lighting fittings, all types of light duty power operated equipment, or socket or conduit outlets from which such equipment can be fed, can be directly attached by use of the carrier plate and standard conduit accessories.

Large enclosed cable ducts—conduit outlets in any direction. The whole of the interior is available for cable, the two large outer ducts taking principal circuits and the middle, the inter-connections between fittings. The dimensions of the trunking also allow for conduit outlets in any direction. The provision of connector blocks makes it simple to alter the layout of lighting or other equipment. A 4-way 2-pole connector block (patent applied for) specially designed for use in trunking can be supplied if required. A unique feature of Ediswan trunking is the space available for handling wiring after the original installation has been completed because the interior walls which create the three separate ducts are part of the cover strip. They are therefore withdrawn when the cover strip is removed and there is ample space for manipulation.

Suspension, Surface Mounting, Recessing. Ediswan shallow trunking is suitable for all normal methods of suspension; for new buildings it may be incorporated in concrete to form a flush surface, or recessed in plaster or acoustic tile ceilings. Because of its smooth, unobtrusive appearance it is particularly suitable for use in Departmental Stores or Offices.

Cut Costs *Trunking systems of any type normally show substantial savings due to lower labour costs, fewer suspension points, and the elimination of multiple conduit runs. Ediswan shallow trunking gives additional valuable savings because it is designed for use with standard conduit accessories and suits standard lighting fittings—and the cost of the trunking itself (in steel) is only 3/1d. per foot approx. (in 0.1″ extruded aluminium approx. 5/5d. per foot) plus accessories.*



Covered by Patent Applications Nos. 20825/54 30248/54

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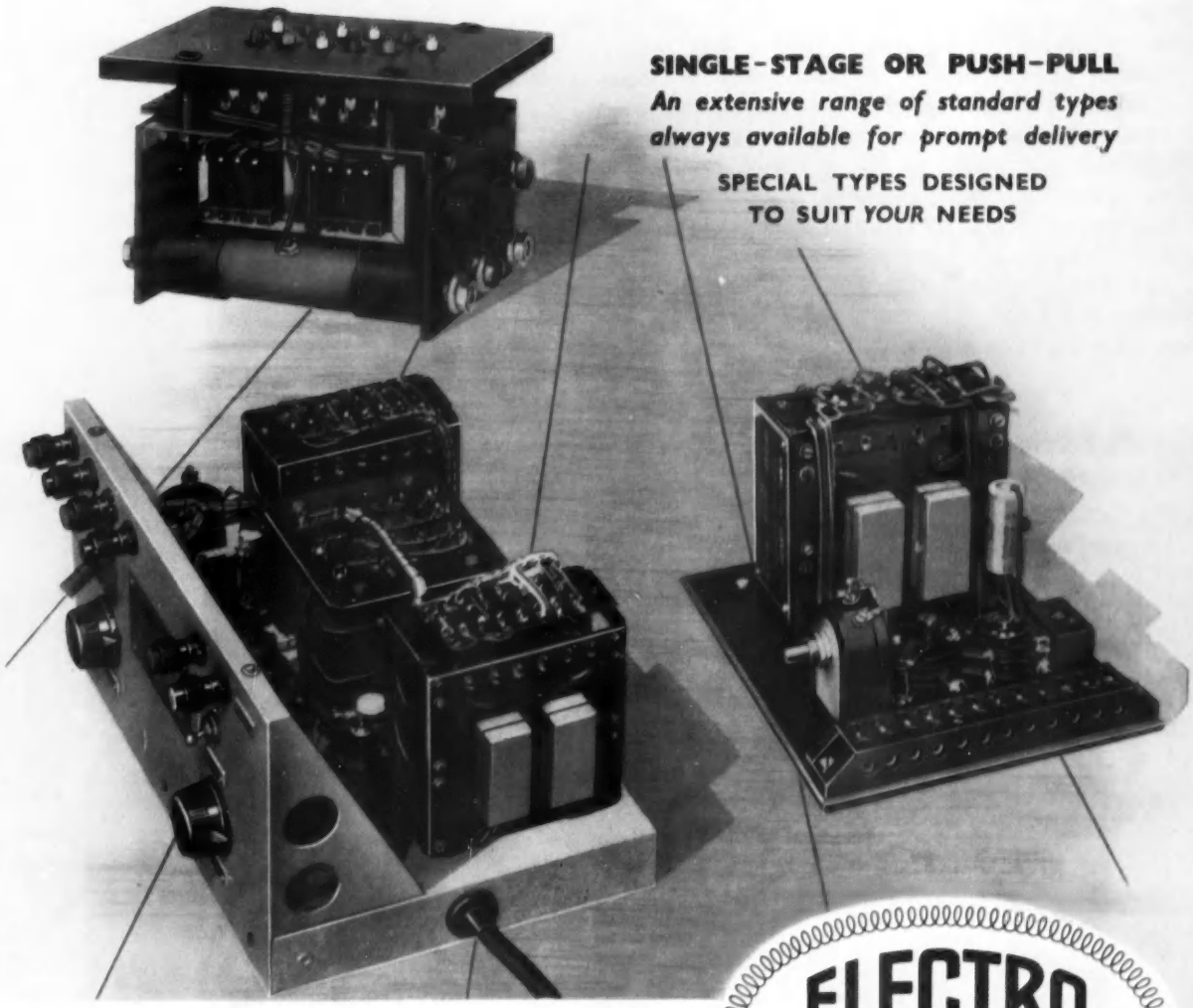

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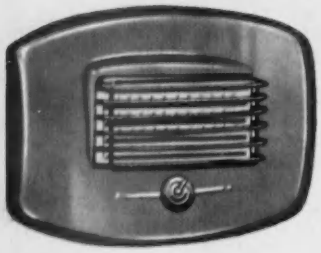

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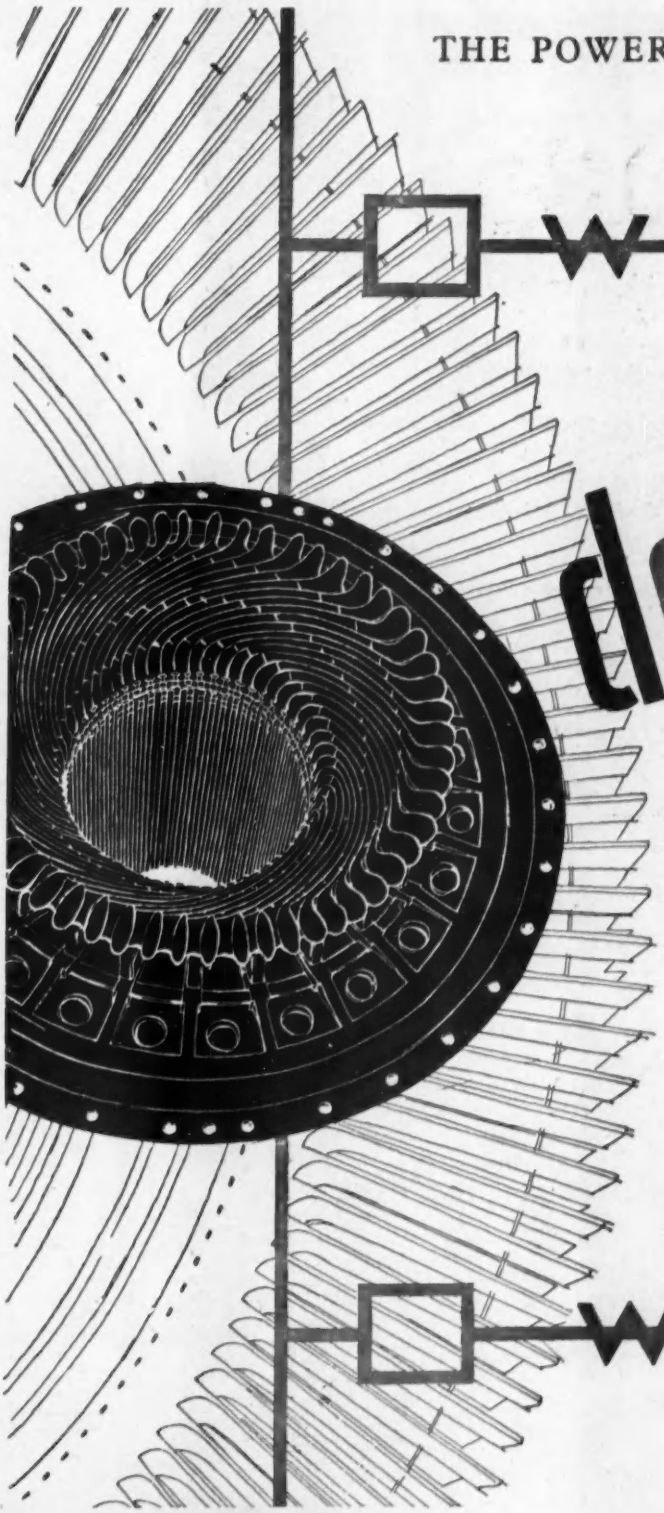

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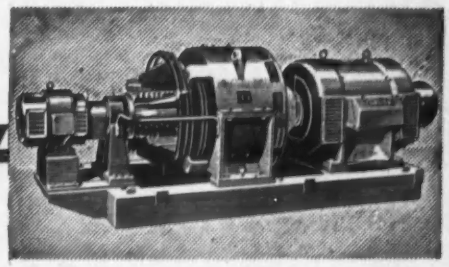

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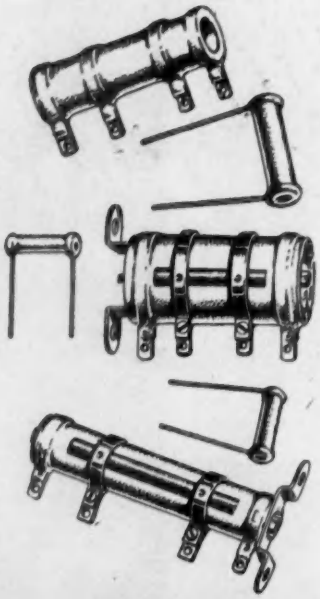

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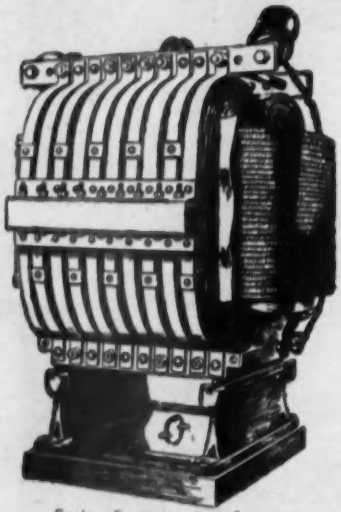

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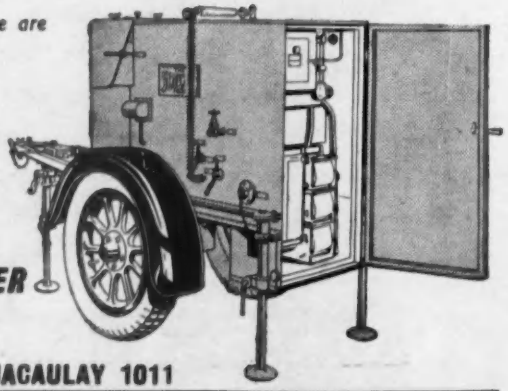

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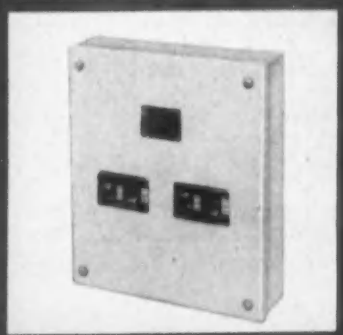

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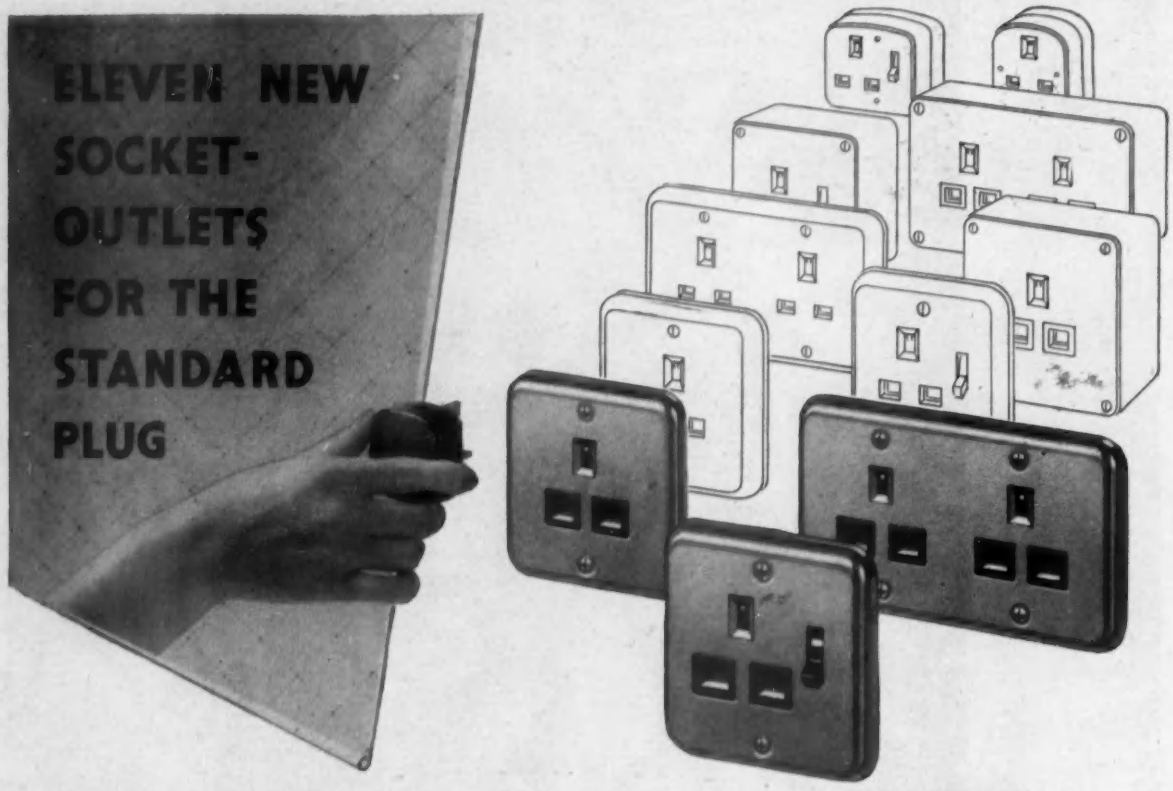

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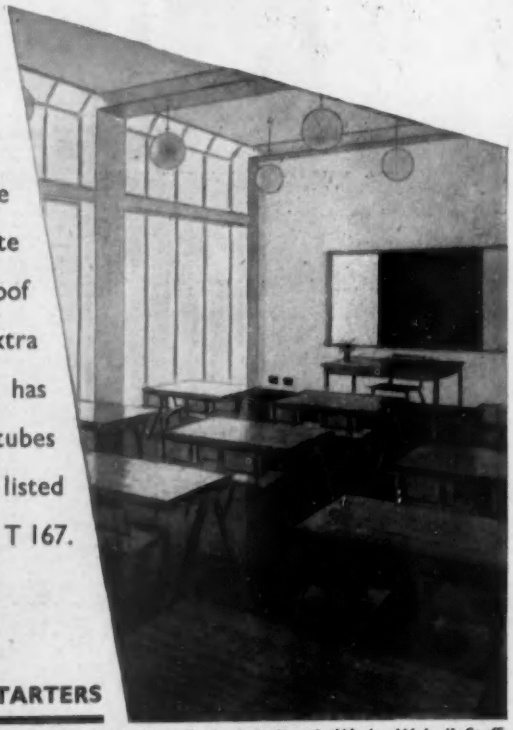

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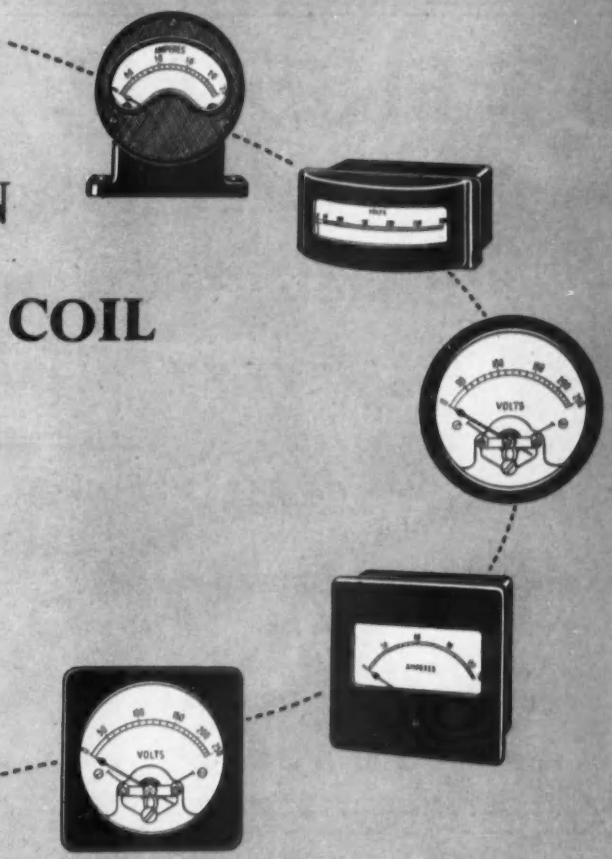

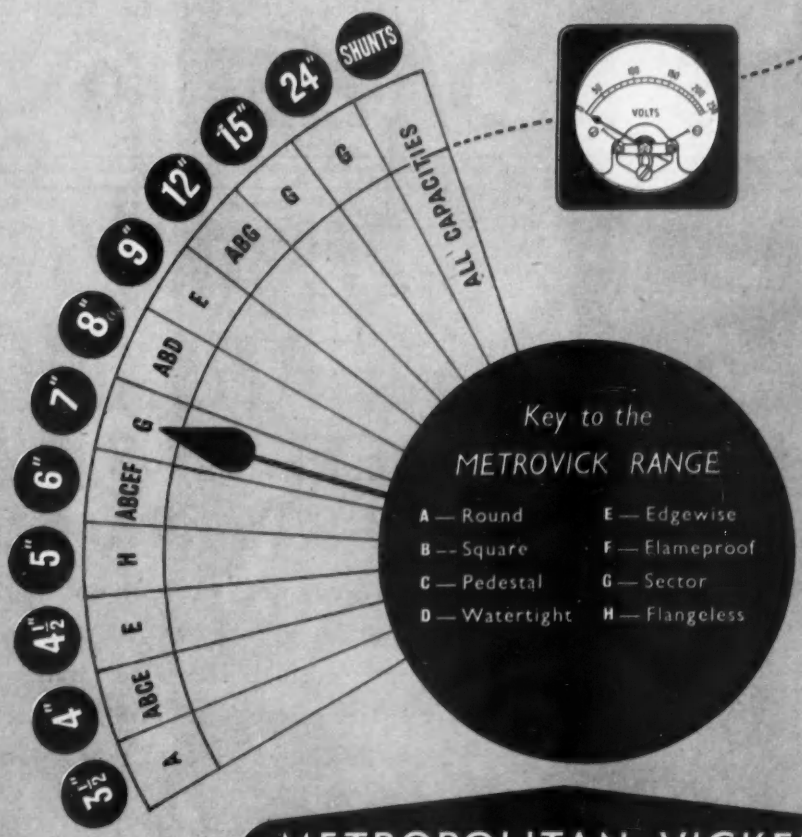

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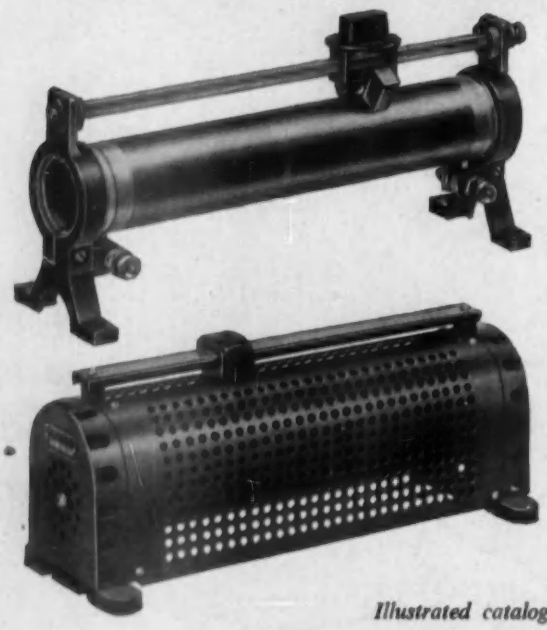

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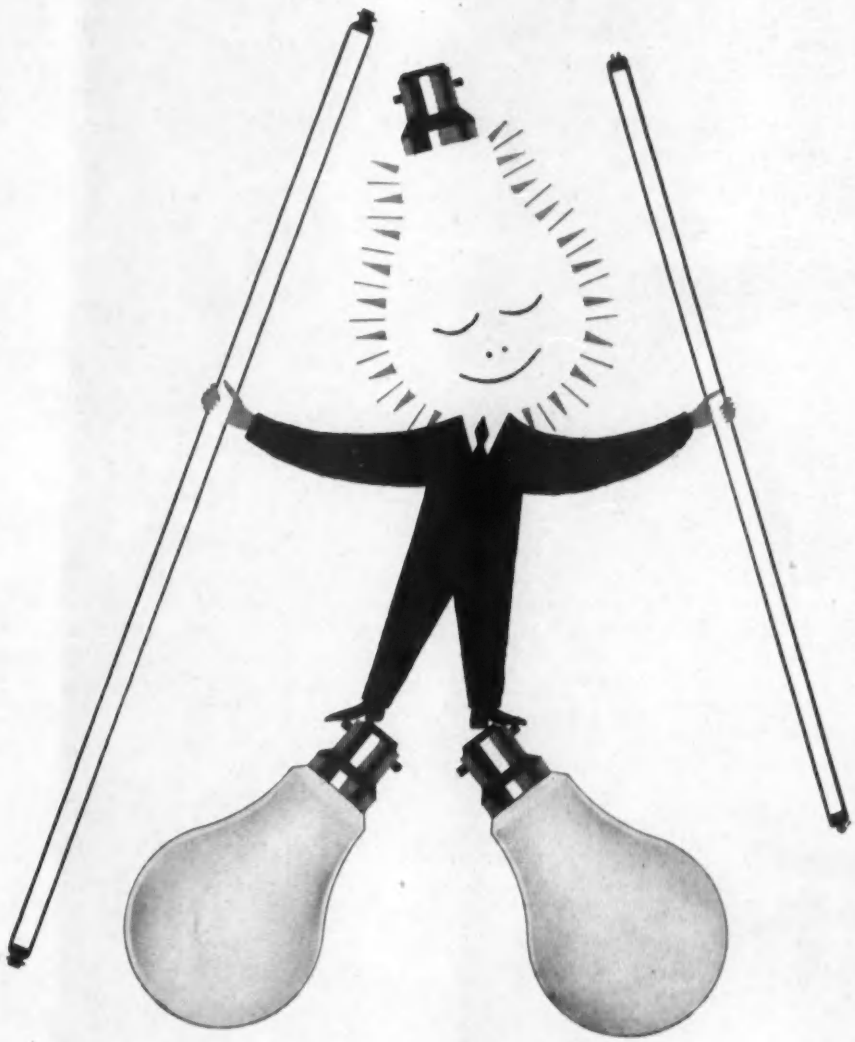

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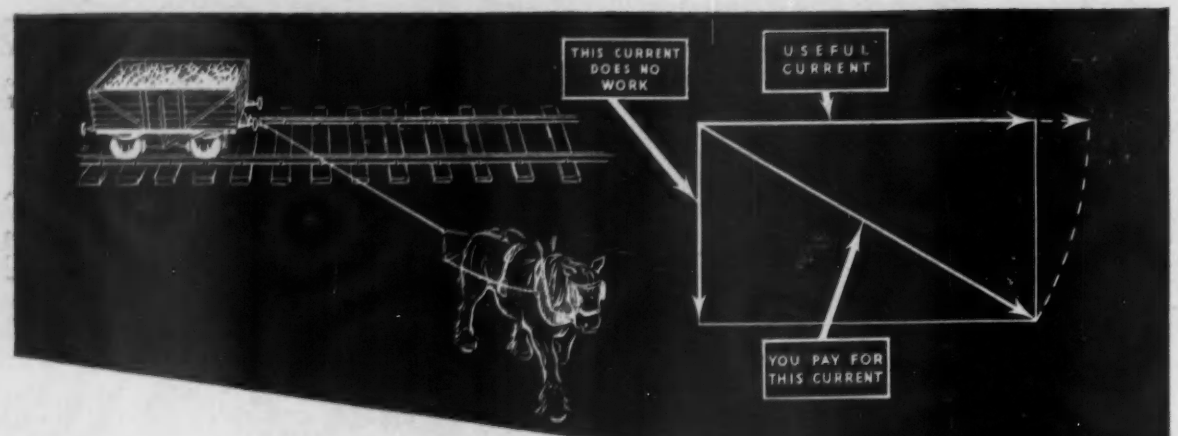

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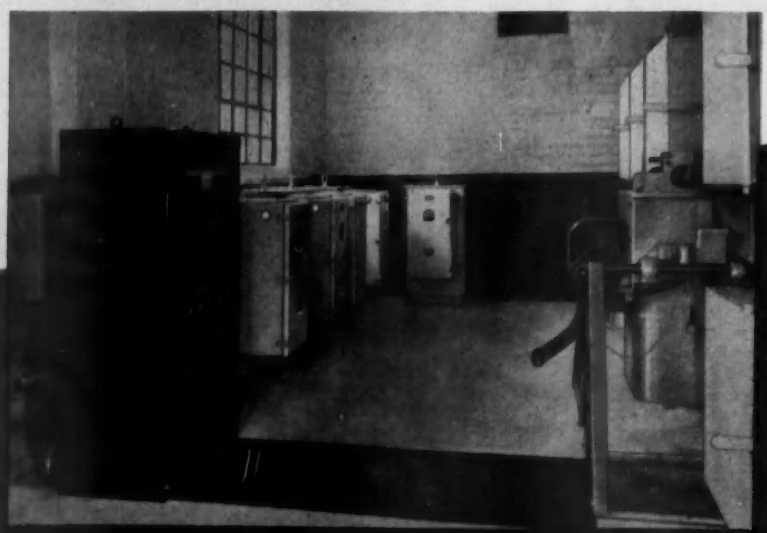

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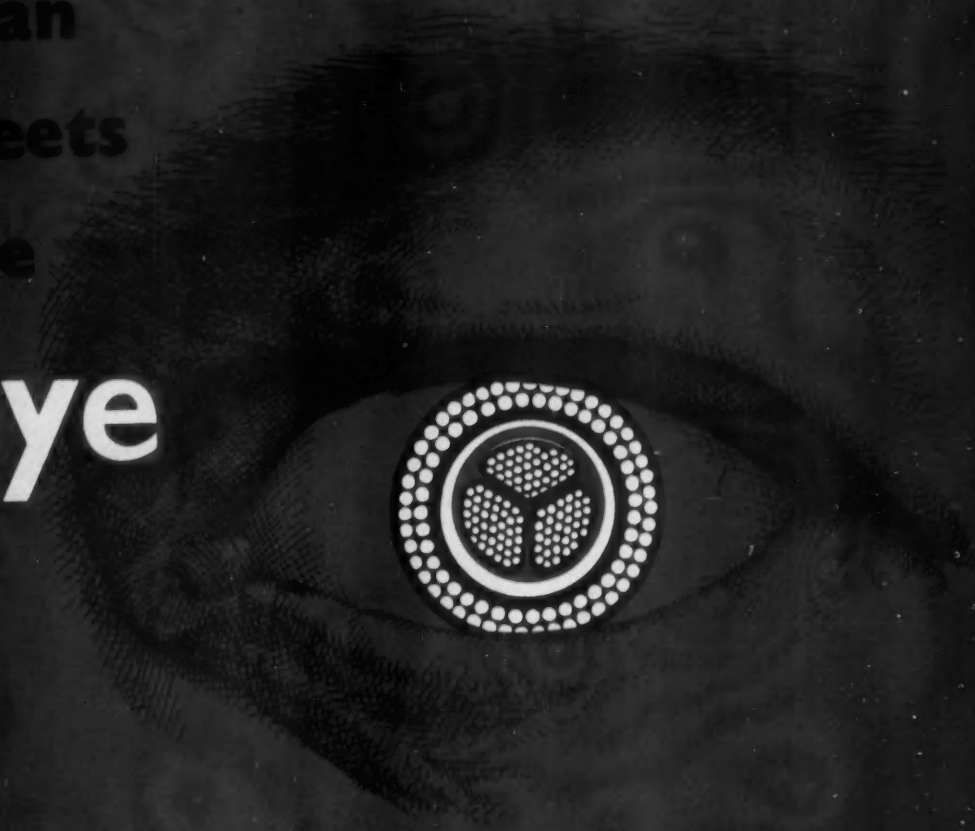

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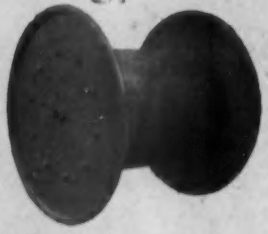

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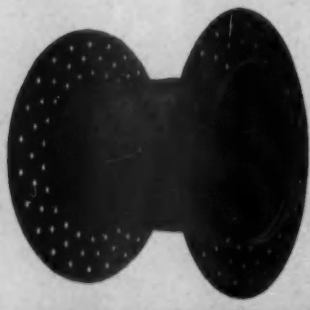

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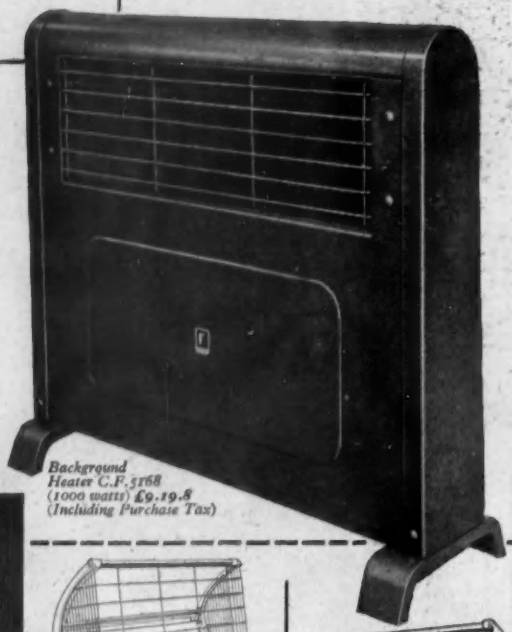

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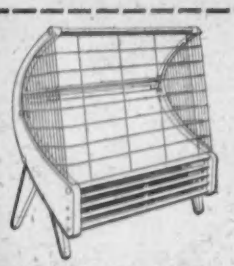
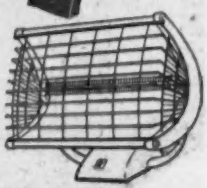


Electric Fire F.3117 (1250/2500 watts) £16.14.7 (Including Purchase Tax)



Electric Fire F.3108 (1000/2000 or 1250/2500 watts) £11.9.5 (Including Purchase Tax)

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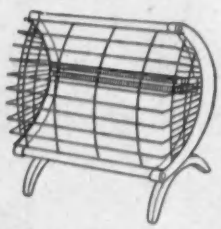
Electric Fire F.4144 (1000 watts) £3.12.10 (Including Purchase Tax)



Electric Fire F.4140 (1000/2000 watts) £8.17.6. (Including Purchase Tax)

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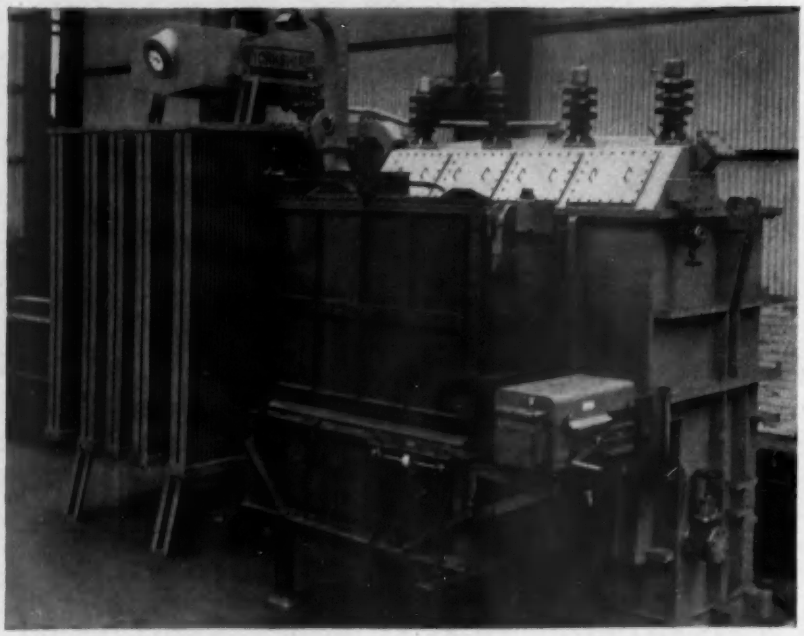

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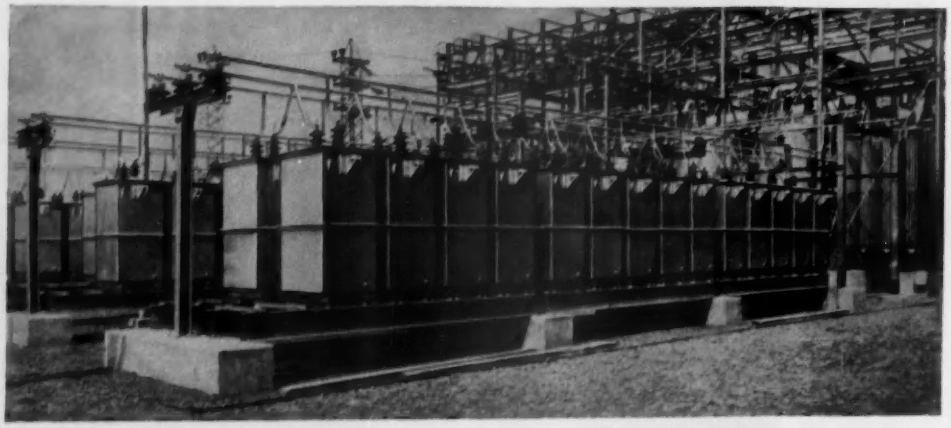

POWER SUPPLY UNDERTAKINGS This bank of BICC capacitors was supplied to the order of the Aluminum Company of Canada Ltd., and is installed on the system of the Shawinigan Water and Power Co. Ltd. It comprises eighty-one 250 kVAr tank-type units, giving a total output of 20,250 kVAr at 10,300 volts. Several banks of up to 15,000 kVAr have been installed on this and other Supply Systems in Canada.

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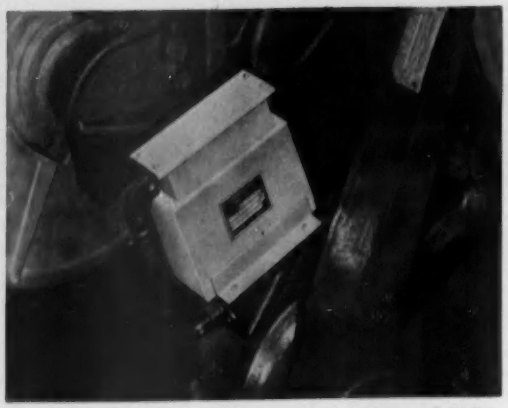

LOOM MOTORS Many thousand kVAr of BICC capacitors are now in use in mills throughout the country. The illustration shows a ½ kVAr capacitor mounted directly on a ¾ h.p. loom motor in the Woodbine Mills of Thomas Walton Ltd., Burnley.

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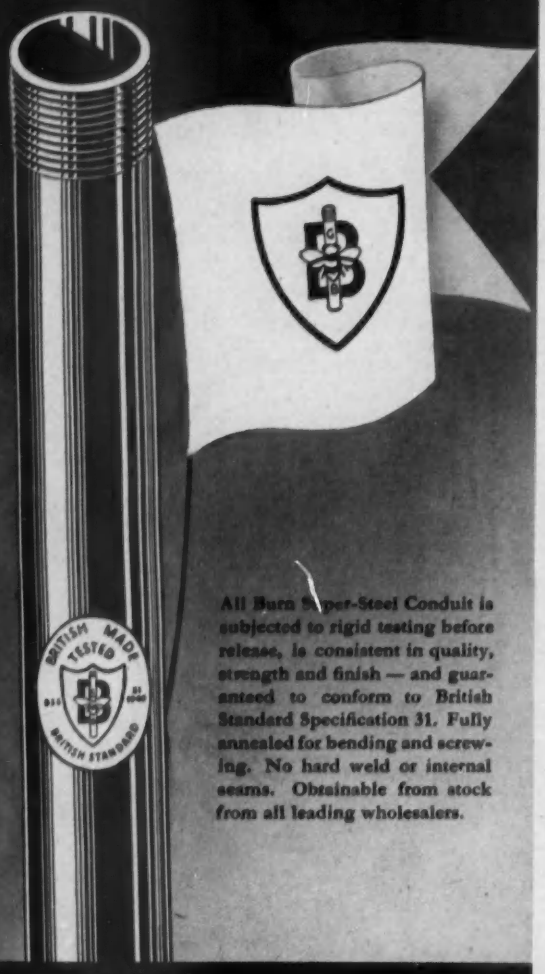

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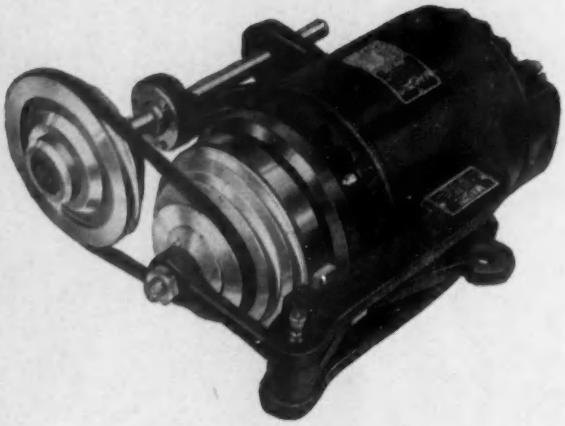
For rapid starting and stopping at 950 R.P.M. 1,425 R.P.M., 2,250 R.P.M.



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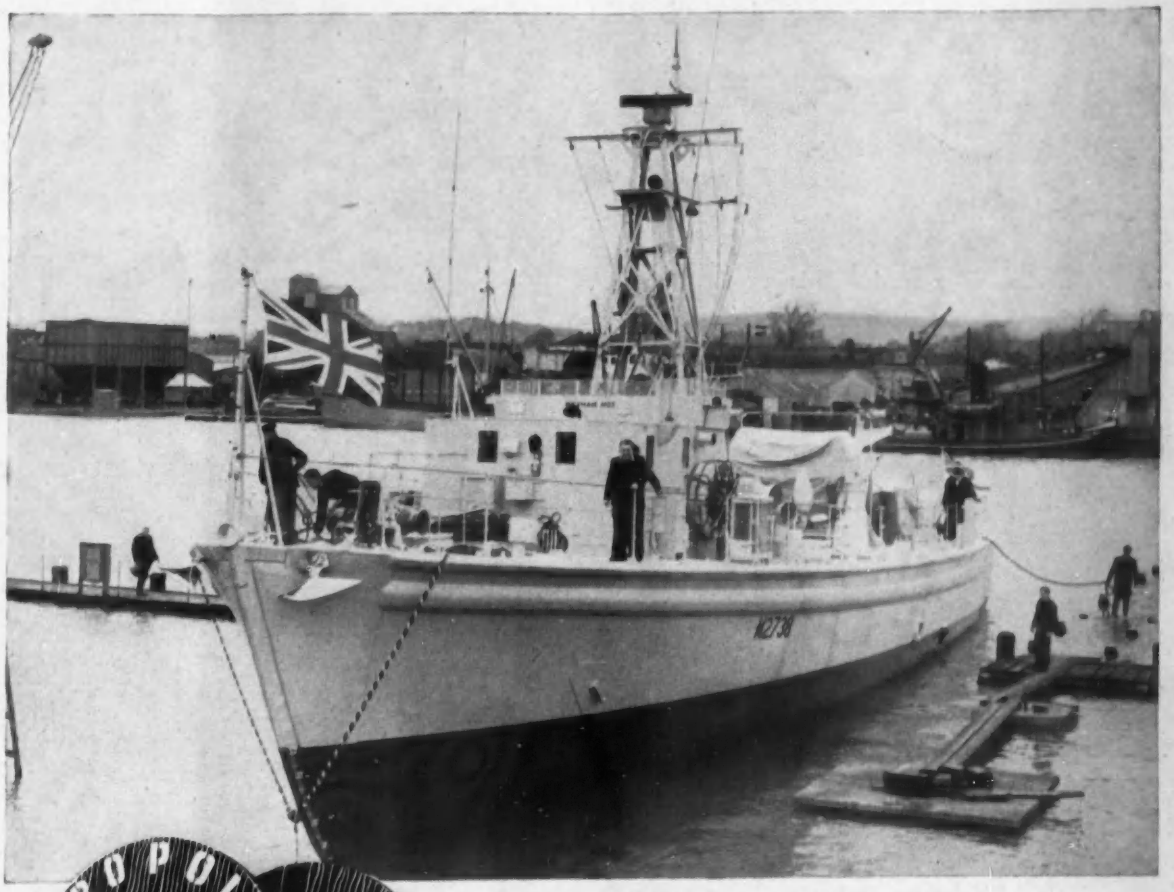

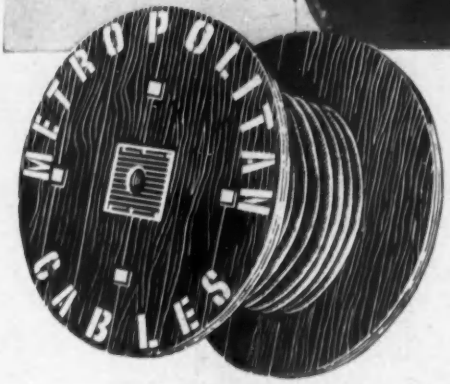

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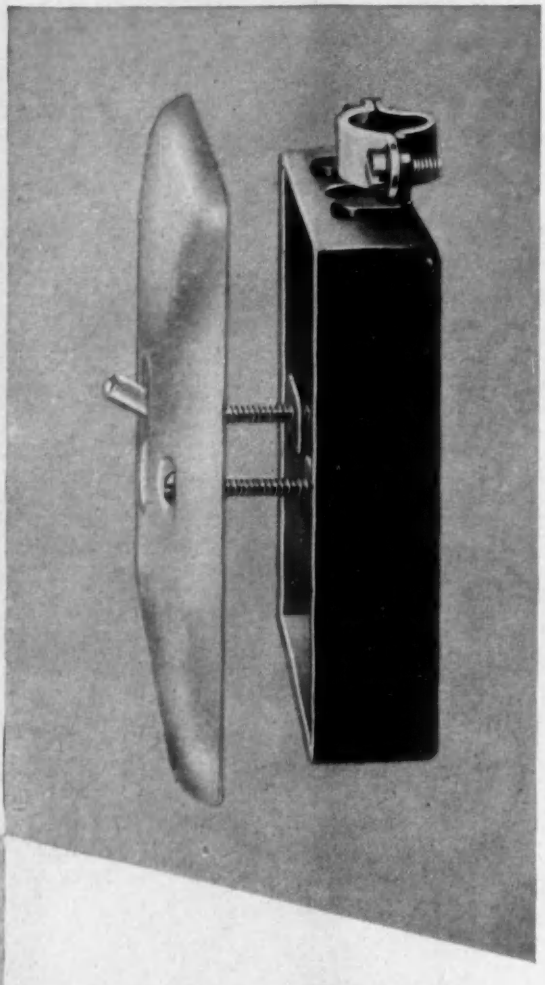

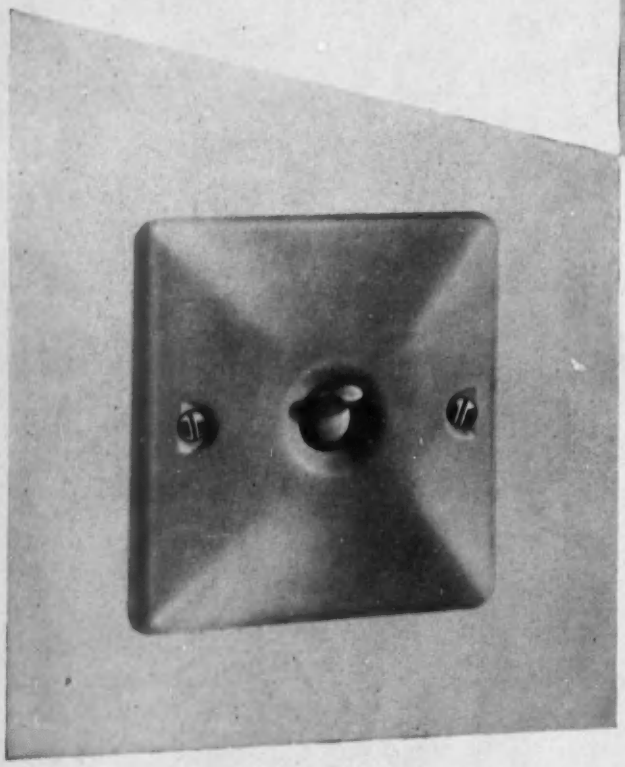

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is provided by the ¾" x 4 B.A. Screws which are supplied with each switch. Full particulars of these switches and boxes are given in Publication S.2544.

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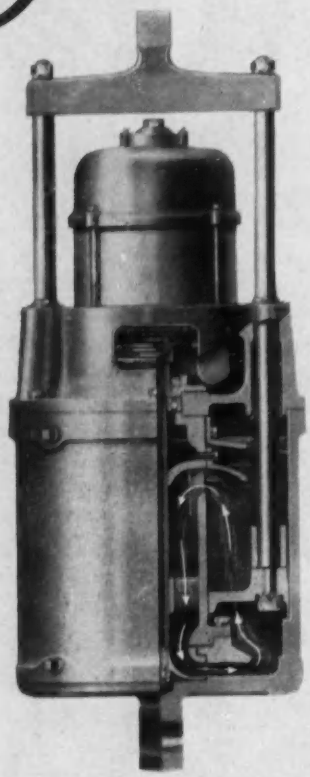

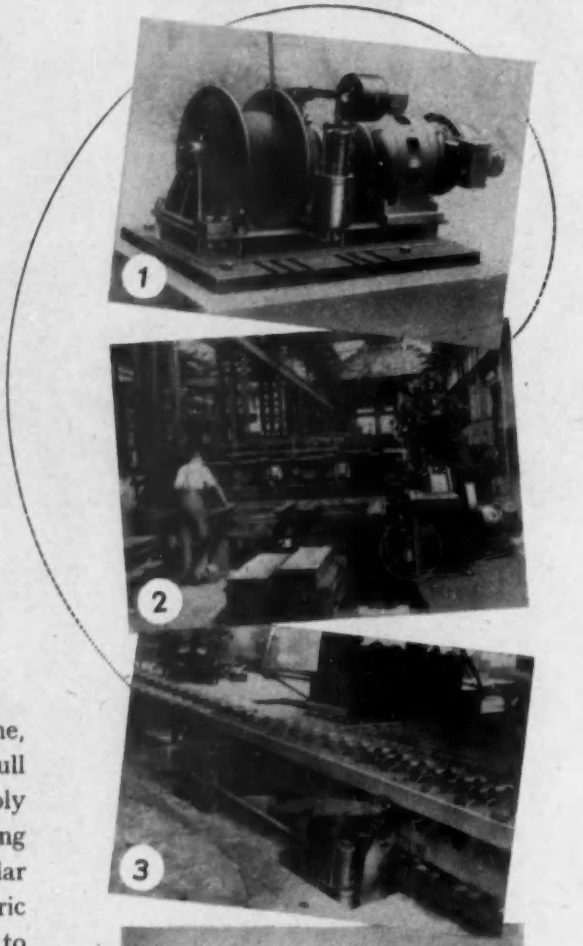

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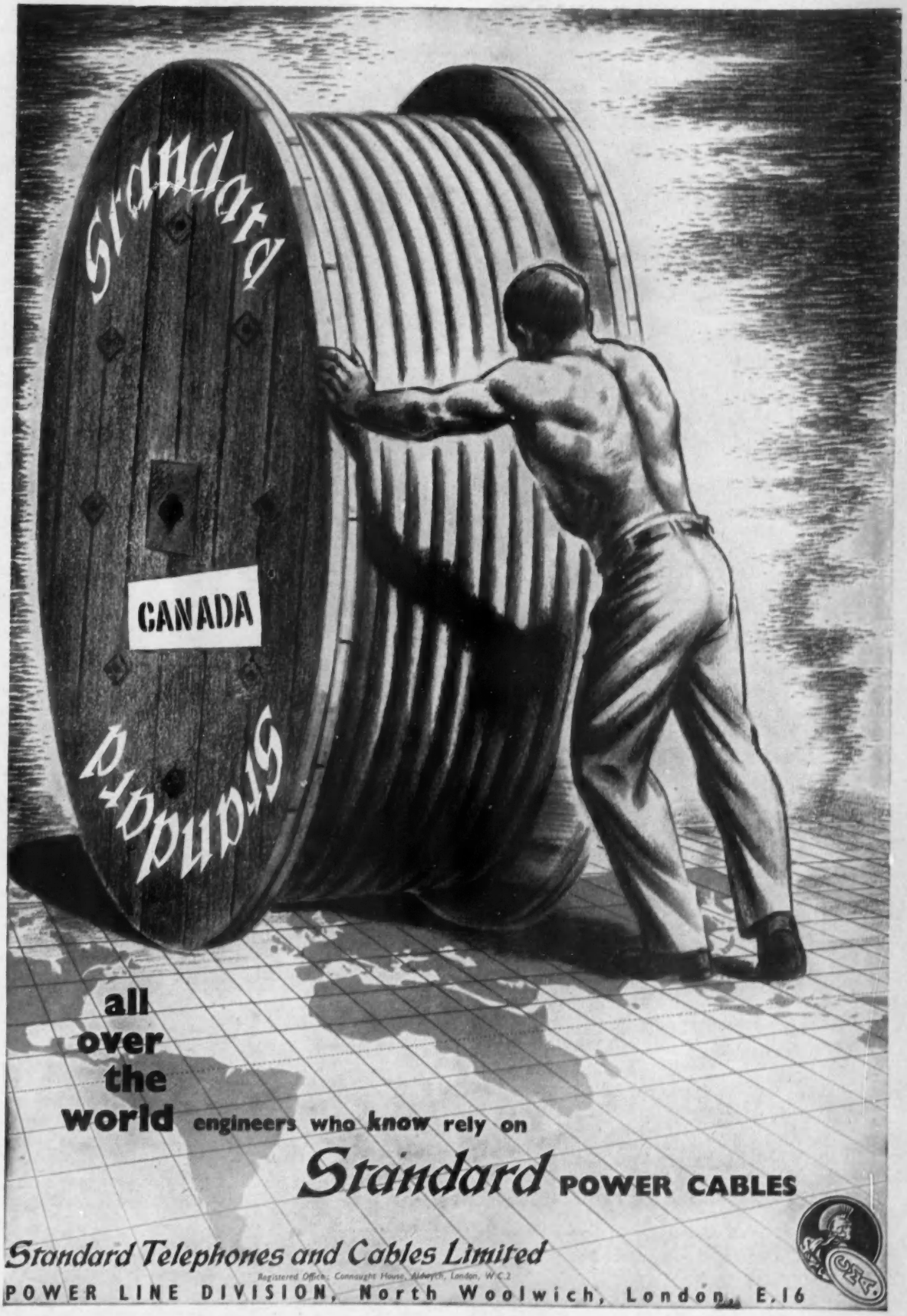

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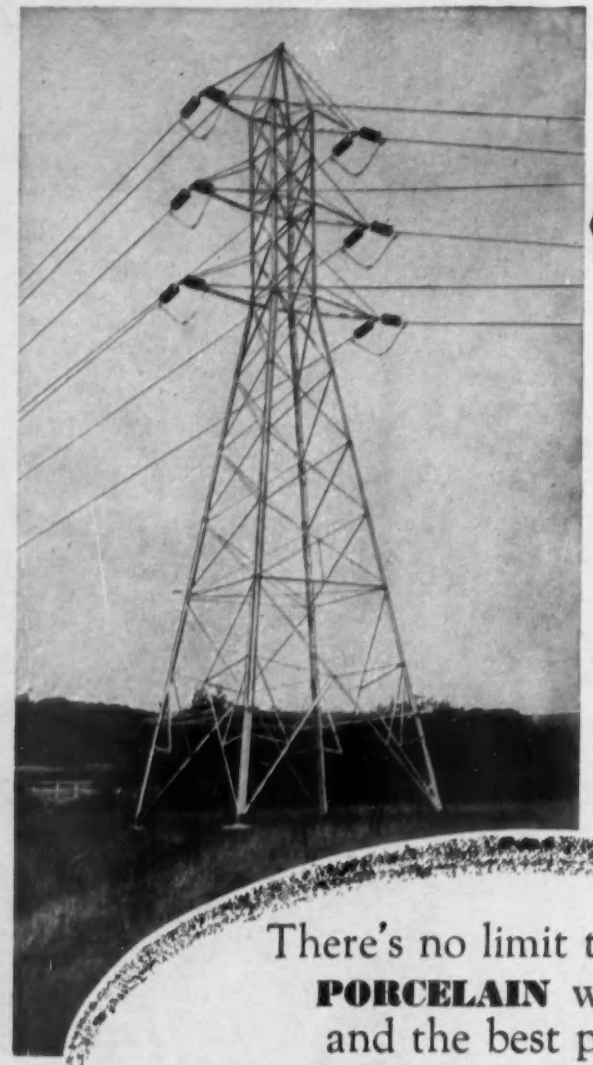

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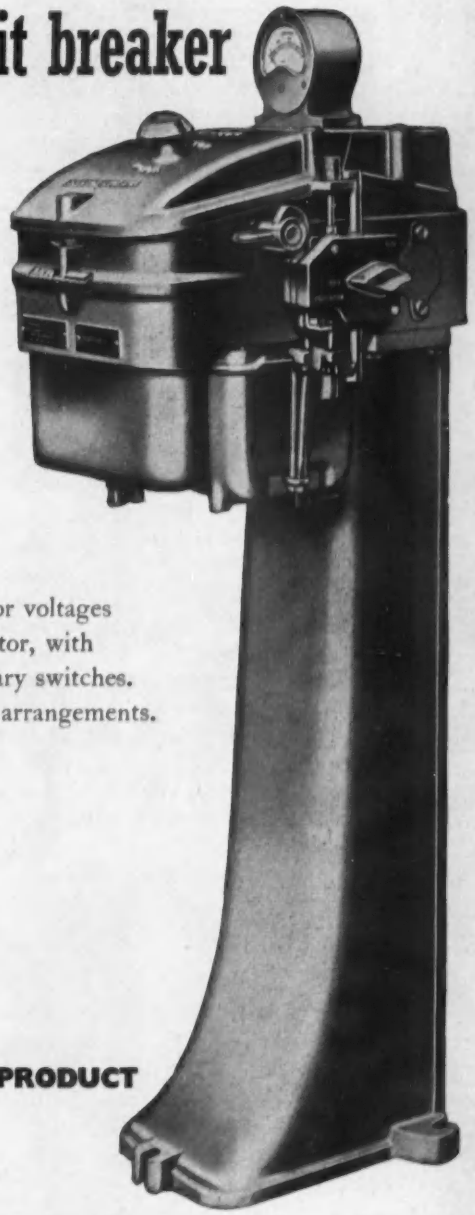

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ELECTRICAL TIMES

THURSDAY, 4 AUGUST, 1955
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NUCLEAR UNVEILING

Four hundred papers are to be read at the Conference on the Peaceful Uses of Atomic Energy, which opens in Geneva on Monday; and a further 600 papers not selected for reading, will eventually reach delegates to the Conference. This rush of information promises to blow away much of the reticence that has marked developments in nuclear engineering, and to bring this branch of technology more in line with normal engineering practice, so far as interchange of information is concerned. Such a development is made more timely by the extended participation of industrial concerns in nuclear projects, for long the exclusive domain of Government agencies. Exposure of established techniques need not weaken competitive power, but should rather accelerate progress, to judge by experience in other fields. Yet free information does not mean that nuclear engineering will become a common undertaking: there are economic and technical barriers which will restrict its practice to the largest firms and organisations. None the less, although participation in the fundamental development work will be for the gifted few, some familiarity with the outline of nuclear power progress will be part of the equipment of all electrical engineers within a few years' time. As always, it is the aim of the ELECTRICAL TIMES to ensure that its readers have the latest information on all important developments here, and as a contribution towards this, one of our engineers will be at Geneva to report on the views expressed at the 84-nation conference, and on the first exhibition of the world's industrial nuclear products. As a curtain-raising service to readers, we present in this issue a review of British nuclear energy plans, and an elementary introduction which concentrates on the power applications of nuclear technology rather than the research and isotope subjects which have previously had most attention.

DOUBLE PRICE INCREASE

Last week's debate in the House of Commons on economic affairs did little to explain why electric domestic appliances have been selectively penalised in the new hire-purchase restrictions. Indeed, apart from a brief reference to excessive pressure being exerted on the metal-using section of the economy by buoyant home sales of appliances, Government spokesmen added little in the way of detailed explanation of the new restrictions. The other arm of the credit squeeze, the call for economies in capital expenditure by the nationalised boards, was treated differently. Here the Chancellor of the Exchequer went into some detail. The generating plant programme is to remain effectively untouched, a decision that

all will endorse, for in new power stations lies the heart of the future expansion of electricity. It is distribution that is to be offered up as a sacrifice, once more, just as it was made to bear the brunt of earlier capital restrictions, yet much expansion, reinforcement and change-over work remains urgent. But it is in reorganising its financial policy, rather than in curtailing distribution projects, that the supply industry is expected to make the largest contribution to the Chancellor's credit squeeze. Mr Butler amplified the statement issued by the C.E.A. on the recent coal price increases. Charges for electricity are to be raised more than is necessary merely to cover the extra cost of fuel: the present spate of tariff increases is designed as well to give the C.E.A. a larger surplus on annual account, so that it will have more money of its own available to spend on capital schemes. This in turn will mean a lessened call on the money market, which is in line with Government policy. The new move involves a modification of C.E.A. policy, and the present consumer will now be required to bear more of the cost of new plant. Nothing approaching the £100m a year the C.E.A. borrows on capital account can be raised from increased tariffs—a total of the order £10-£20m per year seems the probable limit for additional internal financing. Another £6m is available from investing superannuation moneys inside instead of outside the industry, a new arrangement for most nationalised industries which the Chancellor announced. But even the relatively small effect on the national economy of these policy changes will not be felt for a considerable time. The somewhat lengthy process of price raising will delay the appearance of surplus tax in the coffers of the C.E.A. In the interim, before the new prices apply, there is the urgent problem facing the C.E.A. of funding some £180m of short-term borrowing.

SUBSIDIES FOR ELECTRIC HEATING

The Clean Air Bill which was published last week as the Government's substitute for Mr Nabarro's private member's measure, proposes complete proscription of dark smoke, and general permission for local authorities to declare smoke control areas. Solid-fuel appliances in such areas will have to burn coke or some other "smokeless" fuel, and in the past, non-availability of such fuels in sufficient quantities has been the outstanding practical difficulty in establishing smokeless zones. There is little in the present fuel situation to suggest that this position is likely to improve. But this by no means implies that smokeless zones are impractical. Happily for clean air enthusiasts, and for the nation's fuel economy, solid fuel appliances burning hard-to-obtain special fuels are not the only means of avoiding air pollution. The all-electric house has from the beginning been a contribution to clean air, and, in this respect, the Bill itself is encouraging. It proposes that local authorities should subsidise alterations to existing solid fuel fires up to at least 70%, where such alterations are necessary to avoid contravention of a smokeless zone order. Contrary to the impression that some newspaper reports have given, however, the Bill does not seek to limit this subsidy to conversions to coke-burning and other "smokeless" solid-fuel appliances. With the present wording of the Bill, the subsidies will be available to the householder who decides to go all-electric as his contribution to a clean air regime and they should extend to necessary wiring work as well as purchase of the electric fire. For once it seems that electricity has been treated equally with solid fuel.

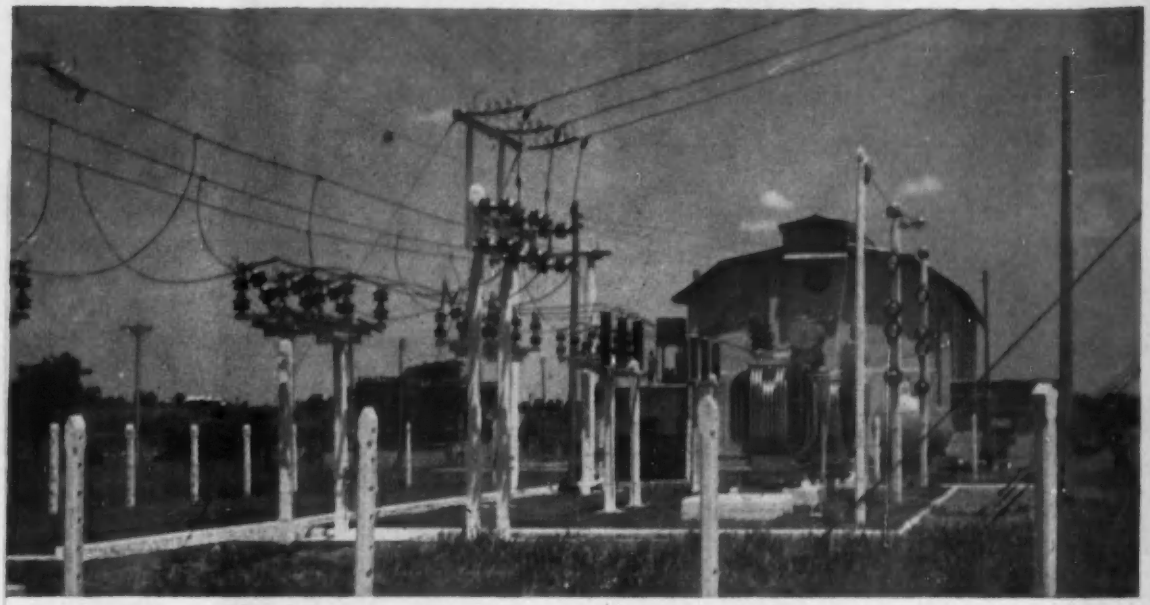
COAL CONSUMERS' VIEWPOINT

The consumers' councils that operate in all nationalised industries have widely varying effectiveness, but there can be few which sway events less than the Industrial Coal Consumers' Council—perhaps because industry with its many trade associations is able to speak up for itself even in conflict with the nationalised might of the N.C.B. In its eighth report, published last week, the Council is reduced to voicing general regret at the recent coal price increases, but it has nevertheless to recognise the necessity for such increases at the present time. For the rest, the report is quite largely concerned with the troubles of the gas boards, and it is a complaint from this source, investigated by the Council which produces one of the few items of interest to the electrical industry. This is a forthright rejection of any claims for a return to the flat-rate rises in coal prices which so bedevilled electricity supply finances during and after the war. There have been continued complaints from gas boards that when the costs of coal mining increase, they have to bear a share of them proportional to the value of the special quality coal they receive. The reply of the Consultative Council expresses succinctly the view which the electricity industry has always pressed in this matter—flat-rate increases are unfair to consumers who buy low-grade coal which is relatively more costly in transport and use.

NIGERIAN PROSPECTS

One of the factors which appears to characterise electricity supply in undeveloped countries is the high rate of load increase. In Nigeria, as Mr J. G. Richardson states in his article published in this issue, the load is currently developing at no less than 23% per annum. At the same time the load density is remarkably low, the majority of consumers having an installed capacity of no more than 100 W. Under these circumstances financial requirements become extremely difficult to meet as heavy capital charges must necessarily be incurred to cater for future load, and the consumer must pay for relatively high overhead costs in proportion to generating costs. When, in addition, other influences such as capital restriction, shortage of skilled labour and high fuel and transport charges are taken into consideration, it can readily be appreciated that the task confronting the Electricity Corporation of Nigeria is indeed formidable. Yet this task must be accomplished if Nigeria is to progress. The export of vegetable oils and fats, which is a major feature of the economic pattern of the country, is dependent on outside influences and although tin mining and other minerals are extracted and exported, it remains essential that secondary industries should be cultivated. These will require an influx of imported skills and capital, and here the provision of ample power supply can make a most important contribution. The Corporation has embarked on an energetic and vigorous policy of expansion, both in generation and transmission in anticipation of this requirement.

Meteor



Ten Years of Progress in Nigeria

By J. G. Richardson,* A.M.I.E.E.

THE electricity supply industry was established in Nigeria at quite an early date, in 1898, when a small 3-phase 50-cycle steam-engine-driven generating set was installed in Lagos.

Very little development took place however until the nineteen thirties, when Undertakings were established in Abeokuta, Ibadan, Kaduna, Zaria, Kano, Katsina, Yola, Jos, Warri, Port Harcourt, Calabar and Enugu. The generating plant was usually installed as part of a combined public electricity and water supply scheme, with the power station an integral part of the water pumping station. The prime movers were mostly reciprocating steam engines, often arranged for the town water to pass through the condensers en route for the town mains. The highest voltage in use was 3·3 kV, except at Ibadan which had a 6·6 kV distribution system, and at Kano where there was a short 11 kV transmission line.

Private Generation

A private company established a hydro-electric scheme with associated 3·3 kV transmission system on the Jos Plateau, mainly for tin mining operations. This system is not a public supply system in the normal sense of the word, as it is mainly concerned with supplying a limited number of mining concerns in bulk at 3·3 kV. It does, however, supply in bulk at 3·3 kV in Jos, Bukuru and Vom for distribution by the public authority. The remainder of this article is concerned only with the activities of the public authority, which was originally the Electricity Branch of the Public Works Department, and its successors. The Undertakings at Ibadan, Abeokuta and Kano were owned by the local equivalent of the town or city council, but were operated and managed by the Public Works Department.

Development came more or less to a standstill during the war years except at the strategically important centres of Lagos and Kano, for which the necessary priorities for the manufacture and delivery of plant and equipment were given. At Lagos a 3,750 kW turbine had been installed immediately prior to the war, and a 5,000 kW turbine and associated boiler was installed during the war years. At Kano a 750 kW turbine was installed, but the associated boiler was lost at sea by enemy action.

Post-war Development

At the end of the war the supply industry was generally in a parlous state. Loads had continued to rise during the war, but no new generating plant other than that at Lagos and Kano had been forthcoming, and distribution extensions had been kept down to a very minimum. Shortage of engineering staff had been acute; the very few people available had to perform extended tours of duty in a very enervating climate. In 1945 generating plant was overloaded and most of it on the point of breakdown owing to inadequate maintenance and spare parts. Coupled with this state of affairs came an unprecedented demand for electricity at Undertakings already established and at centres where no supply existed. It is only within the last few years that the situation has generally been retrieved, but there are still one or two areas where mains are overloaded and generating plant is in difficulties.

A separate Government Department to take over the Electricity Branch of Public Works Department was formed in 1946, called Nigerian Government Electricity Undertakings, and in 1951 a public corporation, the Electricity Corporation of Nigeria took over from N.G.E.U. Many difficulties faced these two bodies; some of these difficulties still persist and are likely to continue for some considerable time.

*Mr Richardson is Superintending Electrical Engineer of the Electricity Corporation of Nigeria.

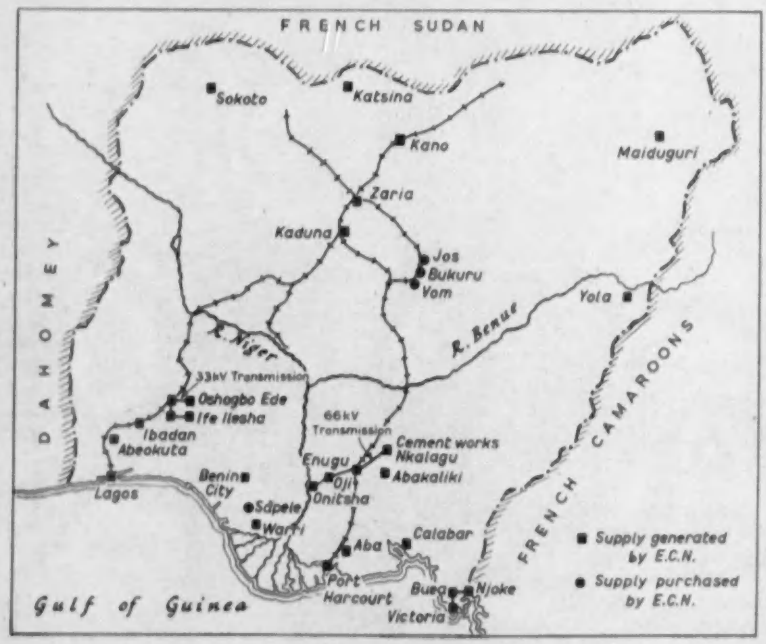
Our heading block shows a 33 kV switching station with the Erinle Power Station in the background. (Oshogbo-Ede Scheme)

Undertaking	Generating Plant KW			Maximum Demand KW		Units Generated (millions)		No. of Consumers		Rates of increase units per annum (Mar. '55)	Remarks
	Installed 1944–45	Installed 1954–55	Under Construction 1955	1944–45	1954–55	1944–45	1954–55	1944–45	1954–55		
										Per cent	
Lagos ...	9,750	17,800	25,000	3,850	14,200	18·58	69·14	10,069	20,814	19·8	Ijora "B" under construction
Ibadan ...	1,000	5,320	5,200	480	2,600	2·13	11·99	1,836	4,980	37·8	
Abeokuta	600	975	—	285	500	1·30	2·72	1,541	2,603	18·5	
Warri ...	120	320	500	70	340	·23	1·22	388	875	24·9	
Enugu ...	2,400	4,320	10,000	1,010	2,330	5·49	12·71	1,718	3,114	14·4	Oji River
P/Harcourt	475	3,310	—	360	1,353	1·41	5·71	2,259	2,354	30·9	
Calabar ...	300	720	—	138	240	·49	1·31	1,006	979	11	
Kano ...	1,350	4,170	4,800	470	2,420	2·27	12·33	2,269	4,888	24·7	Kano "B"
Kaduna ...	550	2,630	—	255	852	1·28	4·52	1,168	2,087	30	
Zaria ...	400	1,380	—	232	560	1·03	2·64	935	1,554	21·2	
Plateau ...	—	—	—	230	1,595	·99	6·78	864	3,417	18·7	Bulk Supply
Katsina ...	50	150	—	37	80	·05	·26	188	376	39	
Yola ...	75	250	—	26	45	·07	·22	136	194	—5·6	
New Undertakings:											
Benin ...	—	330	—	—	210	—	·57	—	641	150	
Sapele ...	—	—	—	—	221	—	1·16	—	733	24·3	Bulk Supply
Oshogbo-Ede	—	—	1,130	—	—	—	—	—	—	—	Supply started 1.4.55
Aba ...	—	1,660	—	—	346	—	1·1	—	711	37·9	
Onitsha...	—	830	—	—	230	—	·66	—	589	120	
Cameroons	—	1,925	—	—	760	—	3·56	—	396	45·8	
Abakaliki	—	60	—	—	37	—	·11	—	149	46	
Sokoto ...	—	150	75	—	82	—	·43	—	285	45·3	
Malduguri	—	550	—	—	138	—	·41	—	480	32·5	
Totals	17,070	46,850	46,705	7,433	29,139	35·22	139·53	24,377	52,214	23·6	

Shortage of engineering and technical staff has always hamstrung development. Engineering does not come easily to the Nigerian and the number of native engineers, technicians and artisans is pitifully small. Consequently a place has had to be taken in the queue for recruits in Europe. European staff is expensive, due to the cost of passages, housing and leaves, etc. The capital cost of electricity supply is high in relation to the wealth of the country. Electricity has had to take its place in the queue for capital with roads, railways and communications generally, hospitals and medical services, education, ports and so on in the allocation of limited capital resources. The continued rise in prices of equipment and costs of shipping and transport has aggravated the position, which, combined with protracted deliveries, has often played havoc with estimates.

Load densities are very low compared with European standards but capital costs are higher. Consumers with a connected load of 100 W or so are in the majority. To maintain a full power station and distribution staff with European supervision, full accounting system, etc., for a maximum demand of under 500 kW is not a promising commercial venture, yet it must be undertaken if electrical development, with subsequent industrial development, is to take place. Distances are vast compared with European standards. When every nut and bolt must be ordered from countries 4,000 sea miles away, and may have to travel a further 1,000 miles or more overland to reach its destination, it is small wonder that delays and shortages are prevalent.

Development has often to be approached from an angle which is not familiar to the European engineer. When a new scheme is entered into, the first operation is often the building of houses to accommodate the supervisory staff for construction. Then local construction staff has to be recruited and trained. Many a power station, transmission line and distribution system has been built with labour which has seldom even seen an electric light before. Due to



Map of the supply area showing generating centres and transmission lines associated with the Electricity Corporation

Erecting a spun concrete support for the Oji Omplia 66 kV line

the shortage of design staff, plans and layouts are frequently very sketchy, and much has to be left to the engineering ability of the man on the spot. Making a reasonably accurate map of the area involved is often the first part of a new project. An engineering recruit from home, used to a limited sphere of activity, say distribution in an English city, may suddenly find himself saddled with the whole range of electricity supply from power stations, transmission and distribution systems, accounts and administration down to the collection of bad debts, transport, fuel costs and the like.

However, in spite of these difficulties some quite considerable and real progress has been made in the last ten years as shown in the table on page 154.

Completed Works

The following brief notes are on the generation, transmision and distribution works which have been completed:

Generation: Extensions have been completed of steam turbine plant and coal fired boilers at Lagos, Ibadan, Kano and Port Harcourt to a total 11,750 kW. Old steam reciprocating and old diesel plant has been largely replaced with new diesel plant, which, together with extensions at existing stations and plant at new Undertakings, has aggregated approximately 19 MW. The largest diesel sets are two 1,300 kW. (3-hour peak rating) vee-twelve machines at Lagos. The balance is made up of a variety of sizes, to suit particular site requirements, down to two 30 kW sets at Abakaliki.

The only hydro-electric station is in the British Cameroons, where a 750 kW turbine has been installed at the Njoke River, with provision for a further unit. This set feeds a 22 kV transmission system which connects to two old German stations, of 800 kW and 300 kW, in the vicinity. Water conditions are very variable throughout the year in the area; two of the stations are run-of-river developments and the other has a limited storage, and very careful co-ordination of their operating conditions is necessary to obtain maximum firm power.

Transmission: A forty mile single circuit 22 kV system has been built in the Cameroons as mentioned above, and connects the three hydro stations to load centres at Buea, Tiko and Victoria. The line runs through precipitous mountain country which is very heavily forested, and is subjected to violent thunderstorms and tornados. Two points of technical interest are worth mentioning, firstly that the performance of the arc-suppression coil protection has been exceptionally good, and secondly that v.h.f. radio communication has been found vastly more reliable than land line telephones.

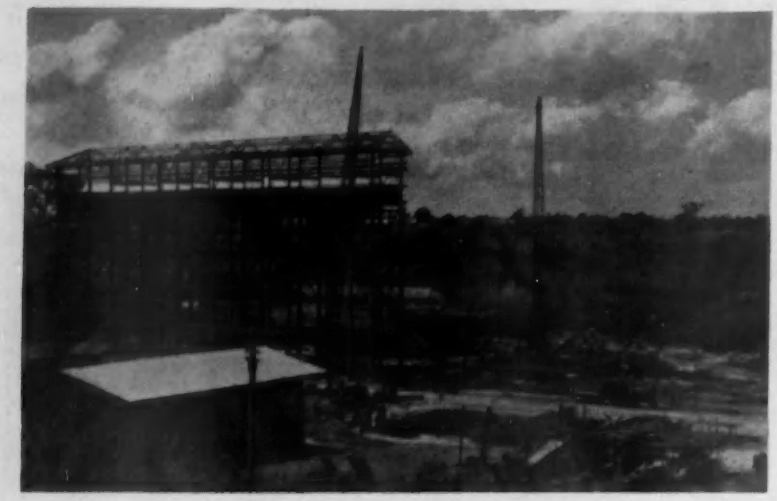
A six mile 33 kV line in Lagos and a ten mile double circuit 33 kV line in Kano are the only other lines in full operation to date, but a fifty mile 33 kV system and an eighty mile 66 kV system are under construction at Oshogbo-Ede and Oji River respectively as described later.

Distribution: Distribution systems in Nigeria are generally overhead, but an extensive h.v. cable system exists in Lagos, and smaller ones in Enugu, Kaduna and Port Harcourt. L.V. distribution in these Undertakings is almost entirely overhead, however.

Considerable extensions and reinforcements have been carried out at the pre-war Undertakings, which in many cases has included an increase in h.v. distribution voltage from 3·3 kV to 6·6 or 11 kV. In Lagos, for instance, the voltage has been changed from 3·3 to 6·6 kV and an 11 kV overlay added. Difficulty was experienced in 1946 in distributing 4,000 kW, but the h.v. system has been so strengthened that 25,000 kW could now be carried with little further development. The number of substations has been trebled, and now stands at over 90. The l.v. system improvement has tended to lag behind the h.v., but is now receiving priority.

Aluminium conductor is now being used extensively, principally in new areas of supply, where the number of aluminium to copper joints can be kept to a minimum. Aluminium is being used also for house service cables so that the only bi-metal joints are at substations and consumers' cut-outs. Some new Undertakings, e.g., Benin and Oshogbo-Ede are run throughout in aluminium in this manner. Aluminium bangles and anklets have quite suddenly become a feature of local feminine adornment!

A typical substation on the Oshogbo-Ede scheme



Oji River Power Station. Main building area viewed from the East

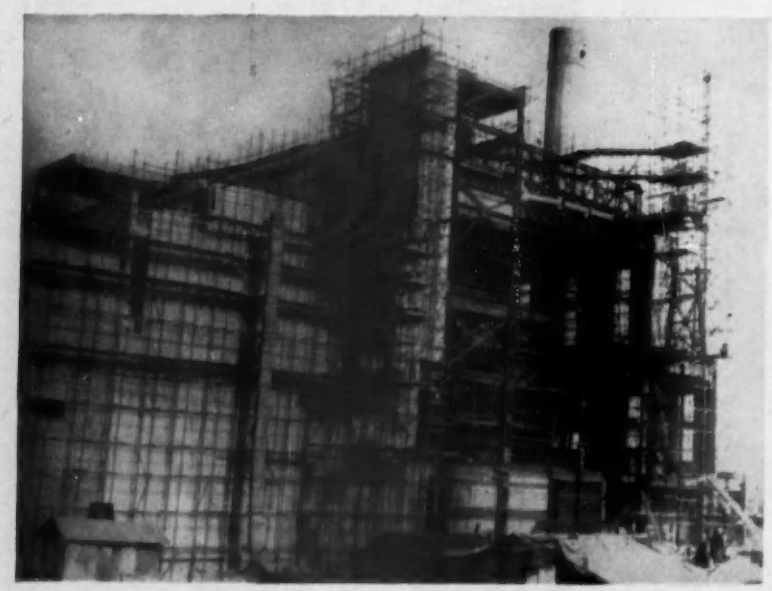
Concrete poles are widely used. Reasonable quality wood poles are difficult to obtain, and are very rapidly attacked by termites. Steel poles are expensive in first cost and maintenance, but have been used quite extensively where ease of transport is of prime importance. Many hundreds of plain reinforced concrete poles cast on site or nearby have been erected, but recently the manufacture of pre-stressed and spun concrete poles has been organised, and the manufacture of plain reinforced concrete poles has virtually ceased. Three lengths of pole have been found to satisfy nearly all requirements, 23 ft for 2/3-wire l.v., 28 ft for 4/5-wire l.v., and 33 ft for 4/5-wire l.v. and 3-wire h.v. on a horizontal crossarm at the top.

Two minor points may be of interest to overseas distribution engineers. Firstly, experience has shown that pre-war 3·3 kV underground cables operate equally as satisfactorily at 6·6 kV as post-war cables designed for this latter voltage, and secondly that h.v. overhead lines with conductor spacings at one time thought adequate for 3·3 kV only can often be operated quite satisfactorily at 11 kV with change of insulators.

Projects in Progress

The major new projects in progress at the moment are new steam power stations at Lagos, Oji River and Kano, an extensive transmission and distribution system fed by a diesel power station at Ibadan.

Ijora "B": The new Lagos station, Ijora "B," is situated within ¼ mile from the old station, Ijora "A" which has been in existence since 1923. It is designed for a final installed capacity of 85 MW, the initial installation being two 12·5 MW turbo-alternators and four 75 klb/hr boilers. The first set is expected to be on load by the end of this year—none too soon when the total installed plant at Ijora "A" of 17·8 MW is having to meet a maximum demand at present over 14 MW, and expected to rise sharply during the forthcoming rainy season.

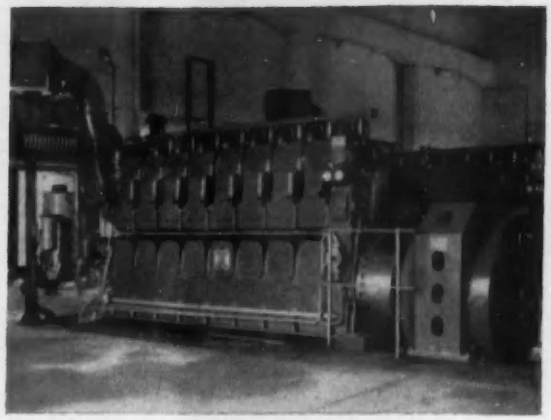


Ijora "B" power station under construction. Main building west elevation

Oji River: The Oji River station is designed for a final installed capacity of 30 MW, the first installation being two 5 MW turbo-alternators and four 40 klb/hr boilers. This station will feed Enugu, Onitsha and a new Cement Factory being built 25 miles beyond Enugu. The availability of cooling water was the deciding factor in the choice of the Oji River site; adequate water is not available anywhere nearer to the Enugu Colliery. Consequently a 20-mile aerial ropeway is being built to transport coal to the station, and practically all the power will be transmitted from the station at 66 kV. A double circuit 66 kV line has been completed to Enugu, and construction of a further 25 miles of double circuit line to the Cement Factory and 35 miles of single circuit line to Onitsha has commenced. The first set at Oji River should be on load towards the end of 1956, again none too soon, as the existing reciprocating steam plant at Enugu is now about 30 years old.

Kano "B": The new Kano "B" station, being built at the side of the old station, will contain, initially, two 2·4 MW turbo-alternators and two 33 klb/hr boilers. Again, cooling water availability was the deciding factor in the choice of site, which is ten miles from the city. The river is bone dry during much of the year, but sufficient water for the adjacent city waterworks and for cooling tower make-up is available from the sandy river bed. A double circuit 33 kV line has been built to take the output of the power stations to the city.

Oshogbo-Ede: Some 150 miles N.E. of Lagos is a very populous area, the economy of which is mainly based on cocoa growing. There is no real industry in the area, but the high population density and comparative wealth of the district has led to what might be termed an experiment in rural distribution. Four towns, Oshogbo, Ede, Ife and Ilesha lie within 25 miles of each other, and have a com-



A 440 kW English Electric diesel set at Erinle Power Station

bined population of nearly 400,000. A modern waterworks has been built to supply Oshogbo and Ede, with an adjacent diesel driven power station to supply power for the pumping plant and the four towns enumerated above. Light 33 kV overhead lines, on pre-stressed concrete poles, link the station to 11 kV and 400 V township distribution systems. The first section of the scheme was put into commission on 1st April last.

Ibadan: Construction of a new diesel station, to be built at the side of the old steam-cum-diesel station, will shortly commence. The building is designed for eight 1,300 kW sets, four of which will be installed in the first place.

The Future

What of the future? The increase in units generated is now running at over 23% per annum, a very high figure indeed, but there is no sign of the demand slackening. By European standards the country is poor and its natural resources are very limited. The postwar boom in tropical produce has brought unprecedented wealth, but the average income is still very low. The ever-increasing use of detergents in Europe might well produce a recession in the palm oil and ground nut trades, two of the mainstays of the country. The other principal exports are cocoa, timber and tin. Cocoa continues to fetch very high prices, but disease in the plantations is not yet under complete control. The timber and tin markets are rather variable. Nigeria possesses the only workable coal deposits within thousands of miles, but high labour and transport costs are beginning to make coal more expensive as a fuel than imported oil over most of the country. Exploration for oil has been in progress off and on since 1936, however, and deposits have been located, but it is not known as yet whether they are workable on a commercial scale.

Industry is practically non-existent. The raw materials for heavy industry do not occur, so far as is known, but there is a wide field for secondary industry; electrical development will depend to a large extent on the establishment of these secondary industries, which in turn must depend upon imported skills and capital. These will not be forthcoming unless there is general confidence in the political structure. Fortunately Nigeria is free of the racial troubles which beset much of Africa, but careful government is required to establish international confidence in the country.

Electricity and Steel Research

NEW EQUIPMENT AT THE SWINDEN LABORATORIES

ADDITIONS have recently been made to the engineering and metallurgical research facilities at the Swinden Laboratories of the United Steel Companies Ltd. These include new electric steelmaking furnaces and an 11 in. 3-high experimental hot rolling mill. The furnace plant, installed by the Electric Furnace Co., comprises three high frequency electric steel melting furnaces capable of producing experimental ingots of 5, 25 and 112 lb respectively. High frequency power is supplied to the furnaces from a motor alternator of Electric Construction Co. manufacture with an output of 50 kW at 9,900 c/s single-phase. This is driven by a 96 h.p. motor running at 3,000 r.p.m. and supplied from a 415 V, 3-phase supply.

Rolling Mill

The rolling mill, supplied by B. Thornton Ltd., is driven by a Metropolitan-Vickers 100 h.p. a.c. motor through a David Brown 4-speed gear box, "Radicon" worm reduction gear and pinions. Billets for the mill are heated by an electric resistance heater, designed and constructed by the research department's staff, and by a 4 ft square hearth gas-fired muffle furnace of "Thermic" design. The mill will roll ingots from the high frequency furnaces into bars for the production of test specimens for metallurgical and mechanical investigations, and will thus assist in the development of new alloy steels and steels for special purposes. It will also serve as a research tool for investigation into the manipulation of steel by rolling and as a test rig for mill auxiliaries, or, where applicable, for the solution of problems arising in production mills.

Mill Capacity

At present, rolls are available for reducing $2\frac{7}{8}$ in. square ingots to $\frac{1}{4}$ in. or $1\frac{1}{4}$ in. rounds and various intermediary squares. A further set of rolls will be available shortly for rolling $4\frac{1}{8}$ in. square ingots to $2\frac{7}{8}$ in. square billets, or various flats in thicknesses down to $\frac{1}{4}$ in. The mill is equipped for the measurement of roll separating force, spindle torque, and rolling temperatures.

The unorthodox practice of rolling a cast ingot to finished round in various qualities of steel with one set of rolls, does not permit the rolling of precision products. It has been found possible, however, to produce a good quality bar which is quite satisfactory for machining into test specimens.

The Swinden Laboratories, erected at a cost of £250,000 were officially opened in July 1952. A staff of 200 is employed, the work being divided into the following main sections: minerals, refractories, fuels and furnaces, iron and steel making plant, forming of metals, metallurgy welding, chemistry, physics and mathematics. The laboratories serve the various iron, steel and engineering branches of United Steel, which together produce some $12\frac{1}{2}$% of the country's iron and steel.

Series Capacitors in Power Transmission Systems

Their Use in the Control of Load Distribution Between Parallel Feeders

By A. SALZMANN, Dipl. Ing., A.M.I.E.E.

FOR many years series capacitors have been used successfully to reduce light flicker in distribution circuits. In these networks the capacitor acts as a voltage regulator, which responds instantaneously, and voltage dip due to load fluctuations caused, say, by arc furnaces, spot welding and various motor drives are eliminated.

Being in series with the distribution circuit, the voltage introduced by the capacitor leads the current by 90° and is directly proportional to the magnitude of the current and opposed to the inductive voltage drop of the circuit. Any change in the load current causes, therefore, a change in the compensating voltage, the capacitor acting instantly as a voltage regulator and being automatic in operation without control gear. The conventional transformer type voltage regulator, on the other hand, cannot respond as quickly to sudden load fluctuations because the voltage drop itself is used to initiate the voltage correction. The same applies to switched shunt capacitors operating automatically, because the leading reactive power cannot be adjusted quickly enough to reduce voltage dip due to sudden load variations.

Series capacitors have corrective effects beyond the point of installation. In the case where several feeders are connected to the same busbars, repetitive load fluctuations on any circuit will cause voltage variations. The capacitor should be placed, therefore, in the transmission line ahead of the substation in order to remove voltage fluctuations on the busbars.

However, series capacitors are no longer merely voltage regulators. They can be used to increase the transmitting capability of transmission lines. Objection against the use of series capacitors on the ground that they modify the characteristic of the transmission circuit is declining because problems such as overcurrent and overvoltage protection, elimination of ferro-resonance effect and many other difficulties have been solved satisfactorily[1, 2].

General series capacitors are employed (*a*) To decrease the impedance of the tie line between power stations by compensating a part of the total line reactance thereby increasing the stability of long distance transmission systems, and (*b*) to balance the reactance of two or more parallel circuits in order to produce the desired load sharing between transmission lines. A series capacitor inserted in the circuit with the larger inductive reactance may secure load division in proportion to the current capacity of each feeder. In addition the capacitor decreases the total reactance of the circuit, thus improves the voltage regulation and stability of the system.

It is proposed to deal in this paper only with the problem of load division between parallel feeders.

Theoretical Considerations

Let us consider a short transmission line without the series capacitor and assume that the load is concentrated at the end of the feeder. (See Fig. 1.) With aid of the well-known vector diagram shown in Fig. 1*a*, it can be proved that the voltage drop on one phase for lagging p.f. is equal to

$$e=(a\text{-}b)=I\,R\cos\phi+I\,X\sin\phi \text{ volts} \qquad \text{.....(1)}$$

where R is the resistance; X is the reactance of the transmission circuit and ϕ the angle between the line current I and phase voltage V_R. Notice *e* is approximately equal to (ed+dc) when it is assumed that ec is parallel to ab, the resulting error introduced by this approximation is negligible. This assumption is justified since the p.f. at both ends of the feeder is about the same, due to the fact that the angle α between sending and receiving end voltages V_S and V_R is very small.

Alternatively, when expressing the voltage drop in per cent we obtain

$$e=\frac{P}{10\,V^2}(R+X\tan\phi)\ \% \qquad \text{.....(2)}$$

where V=receiving end line voltage expressed in kV and P=3-phase active power at the receiving end in kW.

From this formulae follows if the p.f. of the load is low and the reactance X large, the voltage drop is considerably increased, consequently the amount of power transmitted is limited if a certain percentage drop is to be maintained.

When a series capacitor with a capacitive reactance X_C is inserted in the circuit say at location "b" the reactance of the transmission line is reduced from X to $(X-X_C)$ and the total circuit reactance is equal to K.X where "K" is the compensating factor equal to $K=\frac{X-X_C}{X}$. The voltage drop decreases appreciably due to the fact that the second term in equation 2 becomes smaller (K.X tan ϕ). Thus the voltage drop with a series capacitor is equal to

$$e\%=\frac{P}{10\,V^2}(R+K.X\tan\phi) \qquad \text{.....(3)}$$

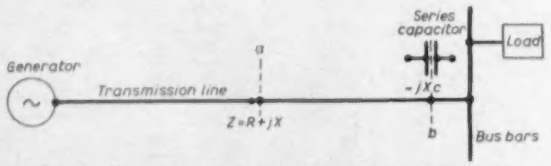


Fig. 1. Single line transmission circuit with series capacitor

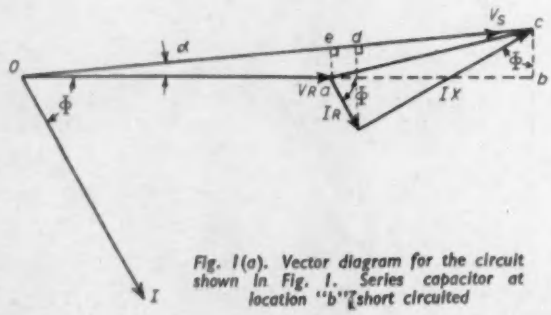


Fig. 1(a). Vector diagram for the circuit shown in Fig. 1. Series capacitor at location "b" short circuited

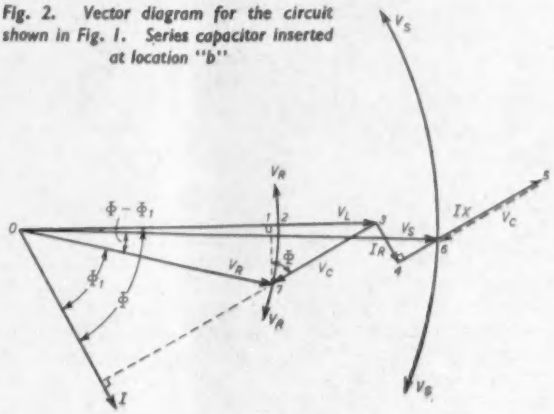


Fig. 2. Vector diagram for the circuit shown in Fig. 1. Series capacitor inserted at location "b"

and the amount of power increased if the voltage drop prior and subsequently to the connection of the capacitor remains constant. From this equation it follows that the lower the power factor (tan $\phi > 1$) the smaller the capacitive reactance X_C required to maintain a certain voltage level. For tan $\phi < 1$ (resistive and reactive load) the capacitor will not reduce the voltage drop by any considerable amount.

The voltage introduced by a capacitor bank is directly proportional to the magnitude of the load current ($V_C = I X_C$) and opposed to the inductive voltage $V_L = I X$ of the transmission circuit, consequently the capacitor voltage will rise the level of the receiving end voltage V_R.

This is illustrated in the vector diagram Fig. 2. The diagram is drawn on the assumption that the sending end voltage V_S, load current I and load current p.f. cos ϕ, remain unchanged and that the capacitor raises the voltage V_R—the voltage prior to its installation—to a value V_L on the load side. When drawing this diagram, we can mark out the load current I which lags behind the voltage V_L (V_L=0-3)—by an angle ϕ corresponding to the p.f. of the load. It should be noted that the sending end voltage V_S remains constant and the locus of this voltage is a circle. In phase with the current is the vector 3-4 (Resistive voltage drop IR) and in quadrature to I but leading is the vector 4-5 (Reactive voltage drop IX).

The inductive voltage drop can be compensated by the series capacitor and generally the degree of compensation depends on the magnitude of the capacitive reactance X_C. In our case it must have a certain value in order to rise the voltage V_R to the level V_L.

By drawing a vector from point "5" perpendicular to the load current I, but lagging, the point of intersection with the sending end voltage circle determines the magnitude of the capacitive voltage V_C represented by the vector 5-6. It is this voltage which is required to raise the voltage level from V_R to V_L. The voltage V_R of the supply side of the capacitor is obtained by drawing through point "3" a vector (3-7) equal and parallel to V_C=(5-6).

Thus the rise of the voltage on the load side of the capacitor is accomplished by introducing a voltage $V_C = I X_C$ and represented by a vector (5-6)=(3-7). However, it must be emphasised that as the load remains constant, an increase of the load voltage causes a reduction in the load current which in turn results in a further decrease of line losses and voltage drop.

From the vector diagram it follows, that the voltage on the load side of the capacitor is increased from the phase value V_R to approximately:

$$V_L = V_R + V_C \sin\phi = V_R + I X_C \sin\phi \quad \text{.....(4)}$$

Actually the exact voltage rise is not $V_C \sin\phi$ but $\triangle e = (0\text{-}3) - (0\text{-}2) = V_C \sin\phi - (V_R - V_R \cos(\phi - \phi_1)) = V_C \sin\phi - V_R [1 - \cos(\phi - \phi_1)]$ and the second term in this formulae can be neglected. Further we notice in Fig. 2 an improvement of the p.f. cos ϕ_1 on the supply side of the capacitor. This is because the series capacitor can be considered as an alternator which generates reactive power equal to $Q_C = 3I^2 X_C 10^{-3}$ kVAR. The capacitor thus relieves the reactive kVA demand on the generating station from P tan ϕ to (P tan $\phi - Q_C$) so improving the transmitting power factor and reducing circuit losses. For constant active power the p.f. of the transmitting power is obtained from $V_L I \cos\phi = V_R I \cos\phi_1$ hence

$$\cos\phi_1 = (V_L \cos\phi)/V_R \quad \text{.....(5)}$$

and is improved in the same ratio as the voltage on the supply and load side of the capacitor.

It should be noted from the equations (4) and (5) that the improvement of the p.f. depends on the magnitude of the

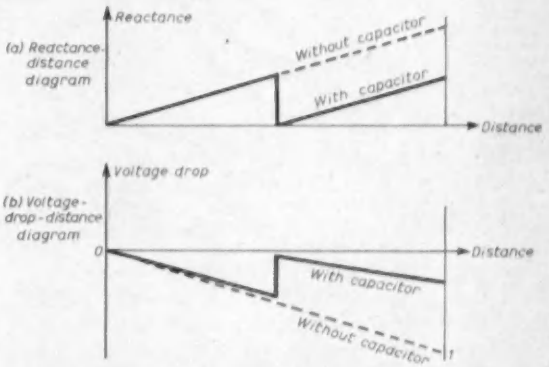


Fig. 3. Capacitor inserted in the mid point of a single transmission circuit. Degree of compensation 0·5

reactance of the capacitor and on the degree of the compensation (1−K) which is the ratio of X_C and the total reactance of the transmission circuit. [$(1-K) = 1-(X-X_C)/X = \frac{X_C}{X}$]. Thus $X_C = 0$ shows the absence of compensation (1−K)=0; $X_C = X$ indicates full compensation (1−K)=1; finally $X_C \lesssim X$ indicates over or under compensation (1−K) $\lesssim$ 1 and the circuit will behave

(*a*) as if the capacitor is removed (uncompensated line),
(*b*) as if resistance only is present in the transmission circuit,
(*c*) as if the effective length of the transmission line is reduced.

For the effective length to be reduced to zero, the total resistive and reactive voltage drop of the transmission circuit will need to be compensated and the value of the capacitive reactance of the series capacitor is obtained by equating

$$I X_C \sin\phi = I R \cos\phi + I X \sin\phi;\ X_C = X + R \cot\phi \quad \text{.....(6)}$$

Figs. 3*a* and 3*b* illustrate the conditions for a series capacitor installation, the capacitor being placed in the midpoint of the circuit and the degree of compensation is (1−K)=0·5.

It should be pointed out, that the degree of compensation (1−K), i.e. the ratio of the capacitor reactance X_C and the inductive reactance X, of the transmission circuit should be less than one. Overcompensation (1−K) > 1 should be given careful consideration before its application in order to avoid resonance conditions.

Control of Load Sharing between Parallel Feeders

Generally overloaded feeders are frequently reinforced by a second feeder operating in parallel. It is not unusual that the length of transmission lines differ; consequently the impedances, and the circuit with lower impedance will pass more current. Control of load division may be therefore desirable in order to limit the current on account of the current rating of the feeder with lower impedance.

This can be achieved by inserting a series capacitor with the reactance $(-jX_C)$ in the branch with the larger impedance as illustrated in Fig. 4 and the capacitor can be placed at any point on the feeder (2). In fact, this circuit represents a closed loop with one load point tapped off at the remote end.

By closing the by-pass breaker (C) the capacitor is short circuited and the natural division of the load current between the feeders is

$$I_1 = I\angle\phi \frac{Z_2\angle\theta_2}{Z_1\angle\theta_1 + Z_2\angle\theta_2} \quad \text{.....(7)}$$

$$I_2 = I\angle\phi \frac{Z_1\angle\theta_1}{Z_1\angle\theta_1 + Z_2\angle\theta_2} \quad \text{.....(8)}$$

ϕ being the load p.f. angle, θ_1; θ_2 the impedance angles of line (1) and (2) respectively.

From inspection of the vector diagram Fig. 5 we note that prior to the connection of the capacitor, I_1 and I_2 lagging the receiving end voltage by angle ϕ_1 and ϕ_2 respectively are the natural currents. Subsequently to opening the breaker "c" (See Fig. 4) the capacitor is

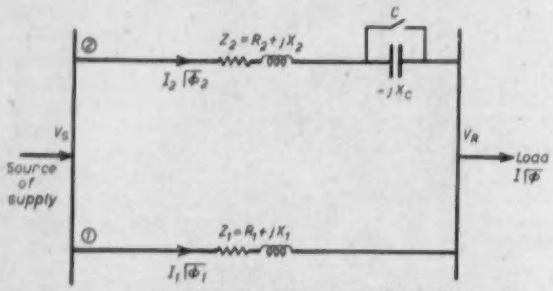


Fig. 4. Current distribution between two parallel feeders and series capacitor inserted only in one feeder

switched into the circuit, and introduces a voltage $V_C = I_2(-jX_C)$. This voltage injected into the loop circuit lags behind the current I_2 in feeder (2) by 90°, and causes a circulating current I_C to flow through the loop circuit. The magnitude of this current is

$$I_C = V_C / Z_{12} \quad \text{.....(9)}$$

where $Z_{12} = (R_1 + R_2) + j\,(X_1 + X_2 - X_C)$ is the loop impedance.

Since the reactance of the loop circuit $(X_1 + X_2)$ is larger than the capacitive reactance X_C the circuit remains inductive and the circulating current I_C will lag behind the driving voltage V_C by an angle α. Superimposing the circulating current on the feeder currents, the current in the circuit with the injected voltage is increased in feeder (2) and decreased in feeder (1).

However, it should be emphasised, that the circulating current I_C lags behind the current I_2 in feeder (2) by an angle $(90+\alpha)$, consequently the current in feeder (2) is equal to $I'_2 = I_2 + (-I_C)$ while in feeder (1) is equal to $I'_1 = I_1 + I_C$.

However, it should be noted that the ratio X/R of each feeder varies assuming dissimilar resistances of the feeders controlled by the conductor size, equal sharing of kilowatts and kilovars is not secured.

For feeders with dissimilar voltages operating in parallel, where one feed has step-up and step-down on-load tap change transformers (see example and Fig. 5) the control of sharing of kilowatts and kilovars is more flexible because of the use of in-phase boost in the transformer feeder.

Example

An existing 11 kV cable shown in Fig. 6 is to be reinforced by a 33 kV feeder with step-up and step-down transformers. Both feeders are operating in parallel and the load of 7·5 MVA at pf 0·8 is connected to the busbars at the remote end, and the transformers are star/delta/star connected having a ratio 33/1·5/11 kV, the delta connected tertiary winding being used to permit unbalanced loading. The rating of each unit is 7·5 MVA, reactance 8% (11·7 ohms referred to the 33 kV volt side) and the resistance of the high and lower voltage windings are 0·88 and 0·075 ohms respectively. Both transformers are linked by a 0·2 sq in. overhead line of length 6 miles, having a resistance 0·22 ohms/mile and reactance 0·54 ohms/mile. Cable constants are: Length 3·32 miles. Cross-sectional area 0·3 sq in. Total resistance 0·485 and reactance 0·42 ohms. Capacitive charging current negligible.

The following information is required:

(*a*) The natural division of load between feeders.

(*b*) Value of capacitive reactance to be inserted in the feeder with the larger impedance for equal load sharing between the feeders.

Natural Load Sharing

Feeder impedance:

(1) $Z_1 = 0{\cdot}485 + j\,0{\cdot}42 = 0{\cdot}641\angle 40{\cdot}9°$ ohms.

(2) $Z_2 = 2\times 0{\cdot}075 + (1{\cdot}32 + 2\times 0{\cdot}88)\,(11/33)^2 + j\left[(3{\cdot}24 + 2\times 11{\cdot}7)\left(\frac{11}{33}\right)^2\right]$ Referred to 11 kV side

$Z_2 = 0{\cdot}485 + j\,2{\cdot}96 = 2{\cdot}99\angle 80{\cdot}7°$ ohms

Loop impedance:

$Z_{12} = Z_1 + Z_2 = 0{\cdot}97 + j\,3{\cdot}38 = 3{\cdot}51\angle 74°$ ohms

Total load:

$P = 7500\angle 36{\cdot}8° = 6000 - j\,4500$ kVA

Load carried by feeder:

(1) $P_1 = P(Z_2/Z_{12}) = 6400\angle 30{\cdot}1° = 5530 - j\ 3210$ kVA

(2) $P_2 = P(Z_2/Z_{12}) = 1370\angle 69{\cdot}9° = 470 - j\ 1290$ kVA

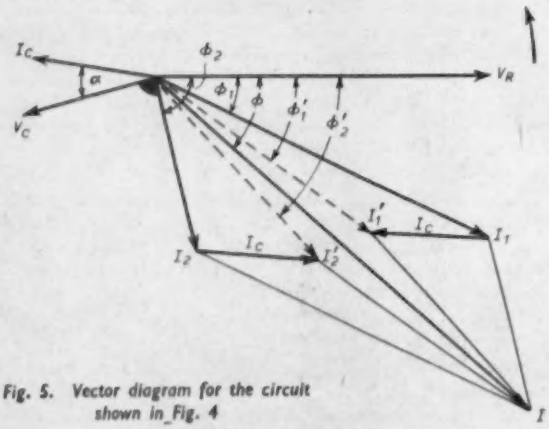


Fig. 5. Vector diagram for the circuit shown in Fig. 4

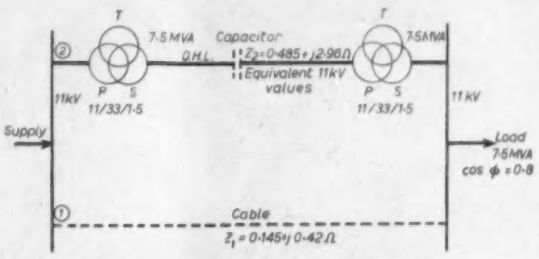


Fig. 6. Single line diagram for parallel feeders. Series capacitor inserted in the transformer feeder

Total current:

$$I = P\angle 36{\cdot}8^\circ/(\sqrt{3}\times 11) = 393\angle 36{\cdot}8^\circ = 314 - j\,236 \text{ amps}$$

Current in feeder:

(1) $I_1 = P_1\angle 30{\cdot}1^\circ/(\sqrt{3}\times 11) = 335\angle 30{\cdot}1^\circ = 290 - j\,168$ amps

(2) $I_2 = P_2\angle 69{\cdot}6^\circ/(\sqrt{3}\times 11) = 71{\cdot}7\angle 69{\cdot}9^\circ = 24 - j\,68$ amps

These results show that the reinforcement will carry only 8% of the active and 29% of the reactive power leaving the 11 kV cable still to carry 92% of the kilowatt and 71% of the kilovar demand.

Equal Load Sharing Between the Feeders

Equal sharing of kilowatts and kilovars is secured if the ratio of reactance to resistance of each feeder is identical. The reactance of the 11 kV cable referred to the 33 kV side is $j\,0{\cdot}42\,(33/11)^2 = j\,3{\cdot}78$ ohms, hence the capacitive reactance of the series capacitor to be inserted in feeder (2) is obtained from $j\,(3{\cdot}24 + 2\times 11{\cdot}7) - jX_C = j\,3{\cdot}78 = 22{\cdot}86$ ohms

Circuit constants subsequent to the connection of the capacitor:

$Z_1 = 0{\cdot}485 + j\,0{\cdot}42 = 0{\cdot}641\angle 40{\cdot}9^\circ$ ohms

$Z_2 = 0{\cdot}485 + j\,0{\cdot}42 = 0{\cdot}641\angle 40{\cdot}9^\circ$ ohms referred to the 11 kV side

$Z_{12} = Z_1 + Z_2 = 1{\cdot}282\angle 40{\cdot}9^\circ$ ohms.

Voltage introduced by the series capacitor:

$$V_C = I_2\,(-jX_C) = 22{\cdot}86\angle 90^\circ\,(11/33)^2 \times 71{\cdot}7\angle 69{\cdot}9^\circ = 182\angle 150{\cdot}9^\circ \text{ V.}$$

This voltage forces a circulating current through the closed loop circuit having the magnitude

$$I_C = V_C/Z_{12} = \frac{182\angle 159{\cdot}9^\circ}{1{\cdot}282\angle 40{\cdot}9^\circ} = -133 + j\,50 \text{ amps} \quad \text{.....(10)}$$

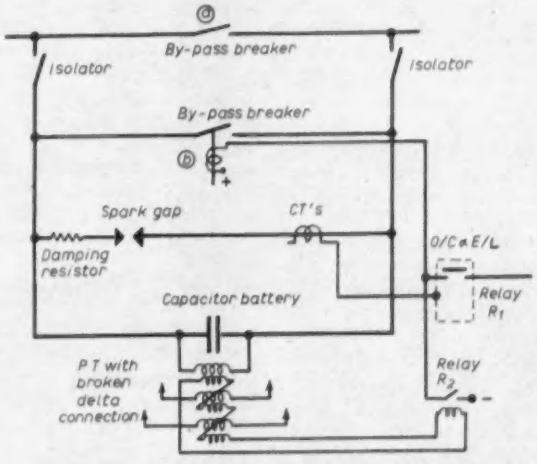


Fig. 7. Protective circuit of a transmission system with series capacitor

Superimposing this current in feeder (1) on the load current we get

$$I_1^1 = I_1 + I_C = 290 - j\,168 + (-133 + j\,50) = 157 - j\,118 \text{ amps} \quad \text{.....(11)}$$

while I_C is to be subtracted from the load current in feeder (2)

$$I_2^1 = I_2 + (-I_C) = 24 - j\,68 + (+133 - j\,50) = 157 - j\,118 \text{ amps} \quad \text{.....(12)}$$

It follows, that equal load sharing between the feeders is secured if the resistances of each feeder are identical, and a series capacitor having a capacitive reactance of $-j\,X_C = 22{\cdot}86$ ohms and a rating per phase of

$$I^2\,X_C = \left[\frac{393}{(33/11)}\right]^2 X_C\ 10^{-3} = 390 \text{ kVAR}$$ inserted in feeder (2). It should be noted that the degree of compensation $(1 - K) = (22{\cdot}86/26{\cdot}67) = 0{\cdot}865$ is smaller than one.

Besides equal load sharing the capacitor reduces the voltage drop of the transmission circuit and consequently rises the voltage level.

Voltage drop: Feeder (2) prior to the connection of the capacitor is $e_2 = I_2\,Z_2 = 215/10{\cdot}8^\circ$ V or 3·38%. The approximate value from equation (2) is

$$e_2 = \frac{P}{10\,V^2}(R + X\tan\phi) = \frac{470}{10\times 11^2}(0{\cdot}485 + 2{\cdot}96\times 2{\cdot}73) = 3{\cdot}44\% \text{ (eqn. 2).}$$

Subsequent to the connection of the capacitor, these values become $e_2' = I_2'\,Z_2 = 196\angle 36{\cdot}8^\circ \times 0{\cdot}641\angle 40{\cdot}9^\circ = 125\angle 4{\cdot}1^\circ$ V or 1·97% or by the approximate method

$e_2^1 = \frac{3000}{10\times 11^2}(0{\cdot}485 + K\times 2{\cdot}96\times 0{\cdot}75) = 1{\cdot}98\%$ from equation (3))

where $K = (X - X_C)/X = \frac{26{\cdot}64 - 22{\cdot}86}{26{\cdot}64} = 0{\cdot}142$

Finally it should be emphasised that the reinforcement of the system by a 33 kV transformer feeder is based on the assumption that the cable will be absorbed in a future 33 kV ring main. This does not mean, however, that the capital expenditure on the capacitor installation will be lost. This equipment can be moved to other parts of the system particularly where troubles are experienced with over-loaded circuits.

Rating and Operating Characteristics

Rating of series capacitors should be based on continuous and momentary maximum line current, ohms and rated working voltage. The latter is equal to the rated capacitor current times capacitive reactance.

In general a bank consists of several capacitor units per phase, each unit having a certain reactance, standard kVAR, current and voltage rating given by the manufacturers. These units are connected in parallel or series-parallel in order to obtain the desired capacitive reactance X_C. Since the voltage introduced by the capacitor is proportional to the line current, it will be necessary to provide a protective device against overvoltage in case the current exceeds the rated value say as a result of overload or a fault beyond the point of capacitor installation.

A typical circuit is shown in Fig 7. The protective device which consists of a special designed spark-gap of rapid response, acts instantly if the voltage rises to an undesirable value. Usually the spark gap breaks down at a voltage equal twice the rated working voltage and thus initiates via the current transformers and the triple pole relay R_1 the closing of the by-pass breaker (*b*). If the relay has an inverse time-current characteristic the capacitor remains in circuit for momentary but not for continuous over-load. After the transmission circuit current falls to normal, the by-pass breaker (*b*) opens because the current in the spark gap circuit is zero, and the capaci-

tor is restored automatically to service. It is seen in Fig. 7 that a second by-pass breaker is provided for removing the capacitor and protective device by hand for maintenance purposes.

The protection of the series capacitor against internal faults is secured by the single pole relay R_s connected to a potential transformer with broken delta secondary winding. At the occurrence of an internal fault the out of balance voltage will initiate Relay R_s to close the by-pass breaker (*b*) thus short-circuiting the capacitor[3].

However it should be emphasised that the protective device may prove unnecessary if the capacitor is selected with an insulation capable to withstand overvoltages. Of course this approach to the problem of rating should be rejected on economic grounds.

If series capacitors are designed to withstand a momentary r.m.s. value of the voltage say equal to 1·5 of the rated working voltage the r.m.s. value of the momentary line current should not exceed 150% of the continuous current rating.

For transmission lines operating in parallel, the series capacitor inserted in the circuit with larger reactance, should be rated to carry continuously the total load current if the uncompensated line is removed by hand from the circuit say for maintenance purposes or automatically as a result of a fault on the uncompensated line.

Regarding the performance of the capacitor under various system conditions it must be emphasised that its presence may cause system disturbances[4].

A capacitor placed ahead of a transformer may impress 50 cycle overvoltages on the primary winding and if exceeding a certain value this voltage will cause transformer saturation in the event of the unit being idle or the load suddenly increased. Saturation may have the effect that the reactance of the transformer is reduced to a value causing ferro-resonance in the transmission circuit with series capacitor.

Safeguard against resonance at supply frequency is by (*a*) locating of the capacitor at a distance from the transformer and (*b*) the reduction of the degree of compensation to a value of less than one, i.e. $(1-K)<1$

Resonance disturbances due to harmonics generated in the transmission circuit are overcome by shunting the capacitor with an appropriate damping resistance. At normal system frequency a very small current will flow through the resistance, but at lower frequencies a large current is by-passed thus preventing resonance effects.

With parallel feeders the conditions are more favourable than for a single transmission circuit because the uncompensated line can be considered as shunt which increases the degree of damping and prevents resonance effects.

One other problem known as the phenomenon of self-excitation arises when starting large induction and synchronous motors in circuits with capacitors connected in series. At a speed less than synchronous speed during the starting period the circuit may become resonant. This danger can be again eliminated by shunting the capacitor with an appropriate adjustable resistance during the starting period.

Conclusion

By installation of series capacitors in the feeder with larger reactance control of load sharing between parallel feeders is secured, transmission capability increased and voltage drop reduced. The capacitor is capable of withstanding overvoltages but should be removed automatically from the circuit if subjected to higher voltages.

The degree of compensation should be less than one in order to avoid resonance conditions at supply frequency. Resonance due to harmonics can be generally eliminated by shunting the capacitor by an appropriate adjustable damping resistance.

Finally, pending system reinforcement investigations should be made for deciding whether elimination of the system disturbances such as higher overvoltages and resonance are technically and economically possible. For these investigations a transient network analyser will prove very useful.

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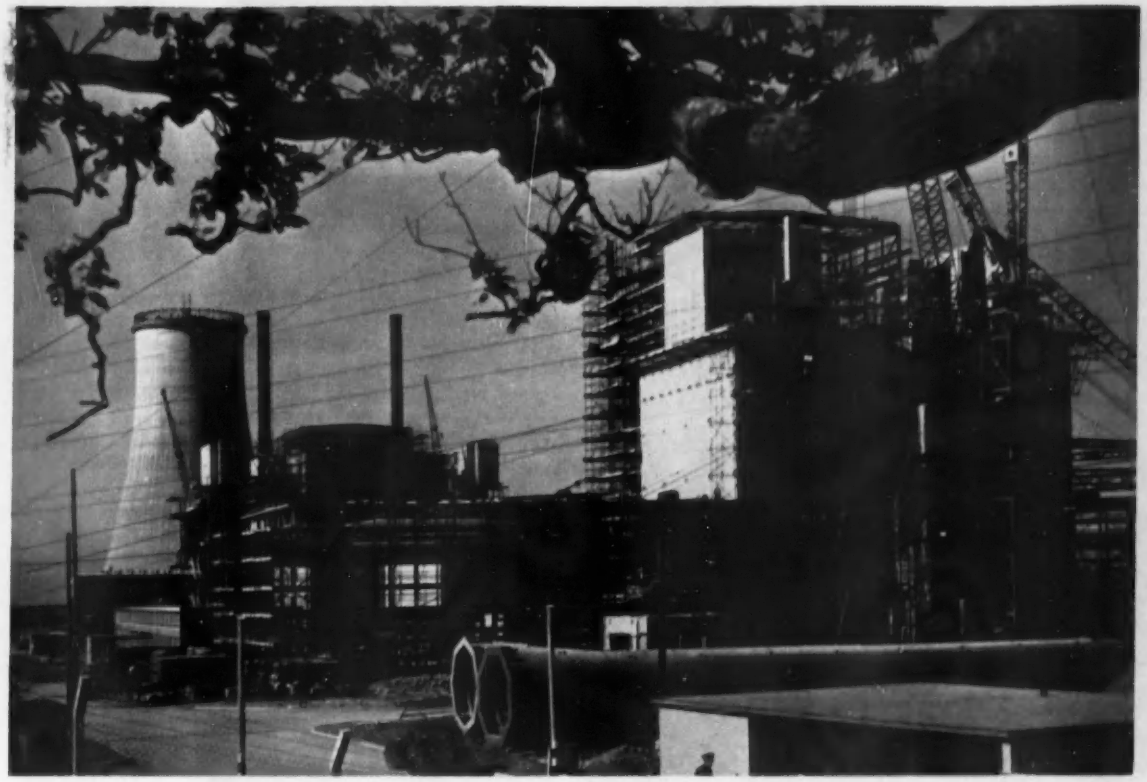
Clean Air Bill

ABSOLUTE prohibition of dark smoke from any chimney is a feature of the Government's Clean Air Bill published last week. This Bill is the successor to the private member's bill introduced in the last Parliament by Mr Gerald Nabarro, and it seeks to implement generally the recommendations of the Beaver Committee on air pollution. The Bill proposes regulations requiring that new furnaces installed by industrial and commercial concerns should be capable of operation without emitting smoke, and that they should be provided with means for minimising emission of grit and dust. Furnaces burning solid fuel at a rate of 10 tons per hour, or any furnace burning pulverised fuel, are required to be provided with plant for arresting grit and dust which has been approved by the local authority. In certain circumstances this latter requirement may be applied to existing furnaces, and provision is made for ordering occupiers of buildings to measure emission of grit and dust.

One of the principal effects of the Bill, if it becomes an Act, will be to allow any local authority to declare any part of its district a "smoke control area." Previously, local authorities have had to promote private acts to give them this power. In smoke control areas emission of any smoke from chimneys is an offence, unless authorised fuel is in use at the time of the emission. When an order declaring a smoke control area is made, owners and occupiers of private dwellings within the area will have to be compensated for the cost of any alterations to their heating equipment that are needed. The minimum repayment is to be 7/10ths of the expenditure incurred "on adaptation in or in connection with the dwelling to avoid contravention" of the smoke control area regulations. It appears from the Bill that the compensation will be payable not only where some approved fuel appliance replaces, for instance, a stool bottomed grate, but also where electric heating is introduced as a means of giving smokeless operation. The relevant section of the Act says that adaptation in connection with which a subsidy is payable include "replacing any fire by another fire or by some other means of heating or cooking." A fireplace is defined in the Bill as including furnaces, grates and open or closed stoves. There is a saving clause restricting the subsidy to "reasonably necessary" expenditure. but adaptations of a higher standard than the minimum necessary will still rank for some subsidy.



NUCLEAR ENGINEERING

A Review of the Basic Technology and Likely Developments

NUCLEAR power stations will occupy a key position in Great Britain's fuel economy for 1965. The power station programme that is now building up is the culmination of work that began in 1945, when the country began to tread its own path in nuclear research after wartime collaboration with the U.S.A. Behind the present advance lies a complex story of development which has made use of all branches of engineering skill.

The first need, apart from research, was the production of fissile fuel. There are three such fuels, uranium 235, uranium 233 and plutonium 239, and the starting point for all of them is U235. This isotope of uranium forms 0·7% of uranium metal, and that metal itself is only obtained from its ores by lengthy processing. Uranium occurs quite widely, with rich deposits in a few places in the world.

A factory was set up at Springfields, in Lancashire, to process the uranium ore, using an acid solution process to give a uranium oxide. After purification, this is subjected to a reduction process which gives the metal required. This, of course, is the natural uranium containing only a small proportion of the fissile U235.

Above is a recent view of the Calder Hall site, under construction by Taylor Woodrow Ltd. Reactor No. 2. is in the foreground. In the background, beyond the administration block and turbine house, is Reactor No. 1 and a cooling tower

For some purposes, particularly military uses, plutonium is needed, and to produce this a factory was built at Windscale in Cumberland. In this, uranium is stacked with a graphite moderator in a reactor core, and allowed to "cook" with the result that plutonium is generated in the uranium rods. Having produced it, it has to be extracted and purified, another long chemical process.

Diffusion Plants

Plutonium has the advantage over U235 as a fissile material that it is easier to separate from the more common U238 in which it is bred, though separation is by no means easy. This is because U235 and U238, in common with all isotopes of one element, are indistinguishable chemically. They can only be separated by making use of slight differences in physical properties. Gases of different molecular weights diffuse through membranes at different speeds, and it is this property which is used to separate U235 from natural uranium at Capenhurst in Cheshire. For this process, the uranium is transformed into a difficult to handle corrosive gas, uranium hexafluoride. This has the advantage, however, that only one isotope of fluorine exists, so that rate of diffusion is determined solely by the uranium isotopes.

As a result of this production effort, built up under the leadership of Sir Christopher Hinton, there has been made available to the British supply industry the materials neces-

sary to a nuclear power programme. The design work for the reactors at the heart of the power station has partly had another source, springing from the investigations carried out at the Atomic Energy Research Establishment at Harwell, under Sir John Cockroft. This establishment has a reactor programme which is directed mainly to the development of reactors capable of giving electric power on an industrial scale. Design studies and related experimental work have given the basic information for the power plants being built at Calder Hall by the industrial group of the U.K. Atomic Energy Authority.

Apart from fundamental investigations, Harwell becomes involved in nuclear power station design because the mathematically intricate process of calculations for a new reactor is not very accurate. The method of proceeding is to determine the lift history of the neutrons in the proposed design to find the reactivity (see pages 165, 169). Theoretical forecasts then have to be tested experimentally by building a small section of the proposed design. This may be subcritical (too small to maintain a reaction, and having some

Part of an electric furnace installation (G.E.C.) at the Springfields factory where uranium is purified for use in reactors

large source of neutrons placed at the base) or zero-energy (developing only a few watts of heat). Relatively little shielding or cooling is required in such experimental reactors, but fairly full control equipment is necessary.

Besides this work on reactors as a whole, Harwell is concerned with testing the materials that are used in their construction. To this end, facilities have been built up for exposing all kinds of potential reactor material to intense beams of neutrons. In such conditions, materials may undergo severe changes in dimensions, and become corroded. Further, the extent to which the materials capture neutrons must be known.

In all this discussion of Harwell, the accent has been placed on work for power generation. It must not be forgotten, however, that the establishment has also been very active in developing the manufacture and application of isotopes for other purposes, such as medical treatment.

Nuclear Power Programme

It is all this work which has led to the programme of nuclear power covering the next twenty years, which the Government announced last February. The first stations to be built are not intended primarily for electricity generation. Now being constructed at Calder Hall, these stations are designed to produce fissile materials for military use, rather than for the most efficient electricity production. Under the Government plan, two further stations of this type (i.e. natural or slightly enriched uranium, graphite moderated, carbon dioxide cooled) but designed primarily for power generation will begin building in 1957, and come into operation in 1960-61. These stations will have two reactors each, and an electrical output of between 100 and 200 MW. Two more stations begun in 1958-59 should again be generally similar, but it seems reasonable to hope for a higher efficiency. This phase of construction should result in some 400-800 MW of nuclear based power being available in regular stations by 1963, with the addition of 100-200 MW from the plutonium-producing reactors being erected at Calder Hall.

In 1960-62 eight further stations may be constructed. Designs depend on progress made in nuclear engineering, which may by then be substantial. In particular, there should be a chance that by the end of this phase liquid-cooled reactors will have become economic.

The Government plan envisages that a large scale prototype of a liquid-cooled thermal reactor can be constructed and fully tested by about 1963, permitting commercial reactors of the same type to be built by 1965. About this date, it is hoped that plutonium may be coming from the early Calder Hall type stations, to be available for use in more advanced types, particularly light-water-cooled and moderated stations.

Another event which may be hoped for by the mid-1960's is the building of a prototype commercial station using the homogeneous reactor. This will not only save money by eliminating many stages of fuel processing, it may also have a small positive gain factor—i.e., produce more fissile fuel than it burns up.

Breeding and Processing

For breeding with a large positive gain factor a fast reactor is required. The experimental reactor now being built at Dounreay has the object of providing this. At present, 1965 is put at the earliest possible date for the operation of such a plant, and 1970 or after for the operation of commercial stations. But although the fast breeder reactor offers the production of more fissile fuel than is burnt up, it does not mean electricity free of fuel cost: the amount of chemical processing necessary prevents this.

Such chemical processing will be necessary to some extent for every type of reactor. The "canned" rods of uranium fuel gradually accumulate fission products, including some that are harmful to reaction operation, and valuable plutonium (see page 165). Sooner or later, a decision must be made to remove the fuel rods and re-process them. Either the waste products can be removed from the uranium, and the uranium-plus-plutonium mixture returned to the reactor; or the plutonium may be extracted chemically, as at Windscale, and used on its own for some purpose. While it is difficult to set a real cost on plutonium, the Government white paper suggested some thousands of pounds sterling per pound avoirdupois. Such a price will have a considerable effect in reducing the cost of electricity production from the early designs of nuclear reactor.

An incidental problem arises in this connection—that of getting rid of the waste products separated out when the "spent" fuel is processed. These wastes are radioactive, some of them having a long life. However, Sir John Cockroft has stated recently that provided the two wastes with the longest life, strontium and caesium, are separated out, the disposal of waste materials will add only 1% or 2% to overall costs. That something better than this may be possible is indicated by the efforts being made by A.E.A. to create an industrial demand for the caesium and strontium as useful and inexpensive radioactive sources.

Nuclear Power in a Thermal Reactor

An Outline of the Neutron Economy

THE basis of operation of a nuclear reactor of the type being built at Calder Hall is simply stated. Uranium rods are arranged in a regular pattern within a structure built from graphite blocks, and a gas is circulated through the structure to remove the heat that appears. This heat is generated because a chain reaction is in process, by which neutrons naturally emitted by the uranium cause fission of further uranium nuclei, heat being one of the products of fission.

Behind this glib summary of reactor principles there lies a host of complications, and it is the purpose of this article to investigate some of these. Without the use of advanced mathematics, however, it is impossible to treat reactor design problems more than superficially.

Moderator Choice

First question which may be considered is, why the graphite? In the type of reactor which is being considered here, this is known as the moderator, and its purpose is to reduce the energy of neutrons. A neutron introduced into a mass of natural uranium may finish up in several ways, and the reactor designer wants as many neutrons as possible to be absorbed in the nucleus of a U235 atom, and to cause fission. The chances of this happening for a given concentration of U235 atoms are far higher when the neutron is moving relatively slowly (at a speed determined by the ambient temperature about—1 mile/second) than when it is travelling at very high speeds (about 6,000 miles/second), as it does when it is "born" during fission. The best way of slowing it down is to let it give up its energy by repeated collisions with atomic nuclei. Laws of dynamics suggest that these nuclei must be fairly light (or not much energy will be absorbed from the colliding neutron) and reactor design demands that they will not capture neutrons. Suitable substances are hydrogen, oxygen, beryllium and carbon. Heavy water (oxygen and hydrogen) or carbon as graphite are the usual choices.

When a thermal neutron (i.e. one moving at thermal speeds) enters the mass of uranium, it may cause fission of a uranium nucleus. In this process, the neutron is absorbed in the U235 nucleus to give a compound nucleus of U236, which is unstable. This quickly breaks up into two main fragments which together have a mass nearly equal to that of the U236 nucleus, and into some neutrons. All these particles are travelling rapidly, because the break-up of the U236 nucleus releases a great amount of energy which shows itself as heat. On average, there are 2·5 neutrons released in each fission.

Fuel Sheathing

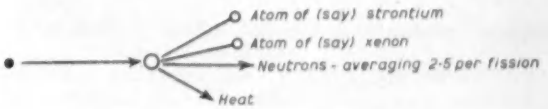
Fission products have great effect on reactor design and operation. It is largely because of their production that the rods of uranium have to be canned. Some of the fission fragments are gaseous (e.g. xenon) and could escape into the cooling gas if they were not contained by the sheath of the fuel rods. It is not easy to find suitable material for this sheathing duty. Gaseous fission products contained within the sheath obviously exert a pressure on it and further stresses arise from the distortion of the uranium metal, which does not undergo thermal expansion equally in all directions. Furthermore in addition to strength under conditions of high temperature and high neutron flux, the canning materials must have the property of not absorbing too many neutrons. Suitable materials are aluminium, magnesium and zirconium.

Neutron Life

The next question likely to arise is, what happens to the two and a half neutrons stated to be absorbed on average for each nucleus of U235 which undergoes fission? Only one of these neutrons is needed for continuing the chain reaction. Remembering that natural uranium, assumed to be used in the reactor under consideration, contains only 0·7% of the fissile U235 isotope, the following list can be made:

(1) A neutron may be absorbed by a U235 nucleus, causing fission. This is the desired event.

(2) A neutron may be absorbed in U238, causing fission. This happens with "fast" neutrons only, and is not very probable.



Nuclear fission and its products

(3) A neutron may be captured by a U238 nucleus to form an artificial substance called neptunium, which in turn decays to give plutonium (Pu239), another fissile fuel. This may undergo fission by absorption of a thermal neutron, or it may remain in the reactor and be recovered later by chemical means.

(4) A neutron may be captured by impurities. This is increasingly likely as the pile grows older, for some of the fission products have a high probability of capturing neutrons. Xenon 135 is a particularly serious example of such a "poison," having a probability of capture greater than any other nucleus. The canning materials and coolant and moderator will also capture some neutrons.

(5) A neutron may be captured by U235 without fission following. About 16% of U235 nuclei that capture thermal neutrons are stated to behave in this way.

(6) A neutron may simply escape from the reactor core.

From the foregoing list, it is apparent that it is no easy matter to ensure that after all losses have been provided for there is the one neutron per fission left for continuing the chain reaction. In fact, the reactor must be built for something more than this, in order to leave a margin for control. This is exercised in the type of reactor considered here by means of rods of strongly neutron-absorbing material pushed into and pulled out of the pile. As an example of the closeness of control required, it may be remarked that if the ratio of neutrons from one generation to the next is as low as 1·002 as it was in the Harwell graphite low energy experimental pile (GLEEP), then the neutron population after 1,000 generations—effectively a small fraction of a second—will have grown by a factor of 7·4. Obviously intricate control arrangements are required, and something is said about this on page 168.

Reactor Development

GAINS IN THERMAL EFFICIENCY AND FISSILE FUEL ECONOMY ARE PROMISED BY ADVANCED DESIGNS

IN the present state of nuclear engineering knowledge, the only way of applying usefully the energy released when nuclear fission takes place is to heat up some working fluid and operate it in a conventional heat cycle. Designs of nuclear reactor at present under consideration thus take account of the need to operate at the best possible neutron economy, but at the same time, seek to extract heat from the fissile fuel at the highest possible temperature, in the interests of thermodynamic efficiency.

Reactor cycles described in this article cover most developments that have so far been suggested, more or less in order of complexity, and also in reverse order of fissile fuel economy. Some of the cycles described have actually been used in experimental reactors: most are at the stage of detailed paper-work investigation. In all cases, the turbo-alternator equipment and associated accessories are assumed to be of conventional design, though often working with less advanced steam conditions than would normally apply in new power plant.

Graphite moderated, gas cooled, natural uranium reactor (Fig. 1)

THIS is the type of reactor which comes first in Britain's power programme. Natural uranium forms the fuel, being contained in metal cans, and a lattice work of graphite blocks provides the "moderator" which slows down the neutrons to the best speed for reaction with the uranium nucleus. Heat is extracted from the reactor by gas forced through cooling passages under pressure. The gas is taken to a heat exchanger where it gives up its heat to water and steam sections which in turn feed a turbo-alternator.

Enriched uranium may be used with advantage in this class of reactor, and helium or carbon dioxide may be preferable to air as coolants. Plutonium is formed during operation of the reactor, and may be extracted chemically from the spent fuel-rods.

Advantages of this design include the ability to use natural uranium, and safety. The safety aspect follows from the fact that if coolant flow is lost, reactivity does not increase. Moreover, the reactor has a negative temperature co-efficient, i.e. its heat output decreases as it gets hotter.

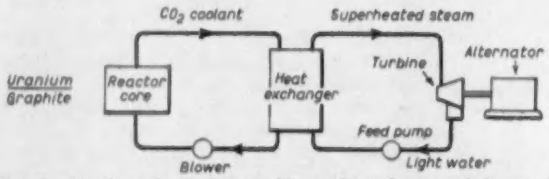


Fig. 1. Simplest of all—the graphite moderated, gas cooled natural uranium reactor

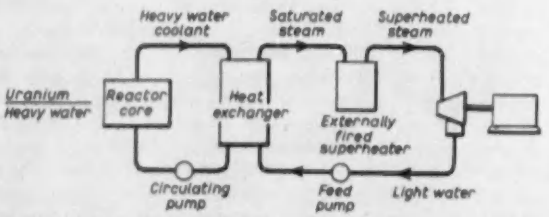


Fig. 2. Heavy water gives the best nuclear economy, but is expensive. An external superheater improves steam conditions

Disadvantages begin with the relatively poor utilisation of the uranium in terms of power—only 1-2 MW ton of uranium. The lattice of graphite in the moderator is very heavy, which introduces constructional problems. The whole large reactor core must be contained in a pressure vessel, if gas flow is to be fast enough to draw off the heat effectively. Pumping power is high, which keeps down effective efficiency.

Heavy water moderated and cooled, natural uranium reactor (Fig. 2)

HEAVY water is the best moderator from the aspect of neutron economy, i.e., the least proportion of neutrons is uselessly captured by the moderator. Thus natural uranium can be used as a fuel, again in the form of metal sheathed rods. The total volume for a given heat output can be smaller than with a graphite moderated reactor, hence a liquid has to be substituted for a gas as coolant. If ordinary water is used, the reactor is inherently dangerous, since loss of the coolant and its replacement by air will increase the reactivity.

Advantages over the gas-cooled reactor include the better utilisation of the uranium. Ratings of 5 to 10 MW/ton may be possible.

Disadvantages are many. Foremost is the large-scale use made of heavy water. This greatly increases the capital cost of the plant. Then in common with all reactors with water coolant, it is not possible to generate steam in the heat interchanger with the degree of superheat necessary for efficient turbine operation. This, however, may be overcome by fitting an externally-fired superheater, perhaps burning oil. Finally, there are many corrosion troubles which complicate the operation of the metal cans in hot water in conditions of heavy neutron flux.

Light water moderated and cooled, enriched uranium reactor (Figs. 3 and 4)

ORDINARY (light) water may be used as moderator as well as coolant, but it absorbs more neutrons uselessly, so uranium enriched with U235 obtained by some separation process must be used, or else plutonium obtained from chemical treatment of the spent fuel from other reactors. An enrichment factor of 20% above the normal concentration of U235 has been suggested. Pressures from 800-2,000 lb/sq in. might be necessary to prevent boiling of the water in the reactor itself.

Advantages. There is a saving in cost of heavy water at expense of enrichment of uranium. Use of light water gives freedom in loading and unloading arrangements. This type of reactor has been stated to be the lowest in capital cost of any type at present envisaged.

Disadvantages are again concerned with high pressure and corrosion troubles, and with superheat difficulties. This type of reactor is not inherently safe.

A modification of the light water moderated and cooled reactor uses a flash boiler in place of a heat exchanger. This introduces some advantages of simplicity, but adds the problem that radioactive steam is circulated through the turbine. Any induced radioactivity is likely to disappear quickly, however, and maintenance should not be impossibly complicated. Because it is radioactive while in operation, however, the turbine must be provided with a biological shield.

Light water moderated and cooled, enriched uranium, boiling reactor (Fig. 5)

THERE are apparent advantages in paralleling the operation of the coal- or oil-fired power station, and arranging for steam to be formed within the nuclear furnace. At first sight, however, ebulition within the reactor core would lead to dangerous instability in reactivity, due to the pockets formed in the moderator by steam bubbles. In fact, preliminary experiments have shown that if boiling becomes excessive, then the expulsion of moderator (water) from the reactor decreases reactivity and even stops it before dangerous temperatures are reached.

Advantages. Heat exchanger and circulating pumps are not needed, and the pressure can be lower than with the other types of light-water-moderated reactor.

Disadvantages. The turbine must be provided with a biological shield, since the same conditions of radioactivity in the steam apply as with the flash-steam system described above. Again, steam is not superheated, and so an externally-fired superheater may be necessary. Some form of pressure-tight building around reactor and turbine seems advisable, to contain products of an explosion.

Graphite moderated, sodium cooled, enriched uranium reactor (Fig. 6)

CENTRAL problem in advanced reactor design is to get great quantities of heat away from a relatively small core. There is a limit to what can be achieved with water under pressure, and much work has been carried out with liquid metal coolants. A sodium-potassium alloy is particularly promising, being liquid at temperatures even below the boiling ponit of water. It has been established that such an alloy does not corrode ferrous metals so long as air is excluded. For pumping purposes, there are possibilities in the electro-magnetic pump, which forces the molten metal along as though it were the armature in a solenoid.

Advantages. High temperatures of fuel elements coupled with rapid heat removal. Because of the high coolant temperatures possible, the steam can be superheated in the heat exchanger. Corrosion troubles are likely to be less than with pressurised water. The reactor itself can be operated at low pressure.

Disadvantages. It is necessary to prevent any risk of radioactive sodium coming into contact with boiling water, so two heat exchangers in series must be used, with additional thermal losses and pumping costs. Use of sodium alloy introduces difficulties in loading and unloading the reactor.

Homogeneous Reactor (Fig. 7)

WHEN uranium is used in metal bar form in a reactor, it gradually accumulates fission products (gases and solids) and plutonium as a result of bombardment with neutrons. The bars must be removed from time to time for chemical re-processing to "cleanse" the uranium and to recover the plutonium. If the uranium and the moderator can be intimately mixed, in solution or slurry form, then some of this chemical processing may be carried out continuously. This is achieved in the homogeneous reactor. One design that has been described uses the uranium as

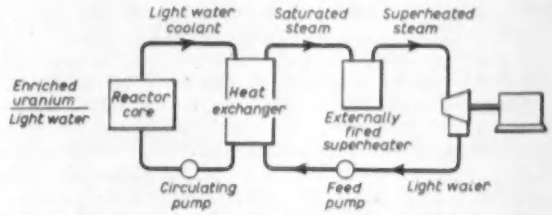


Fig. 3. Ordinary water as moderator and coolant has an effective simplicity, but demands the use of enriched fuel

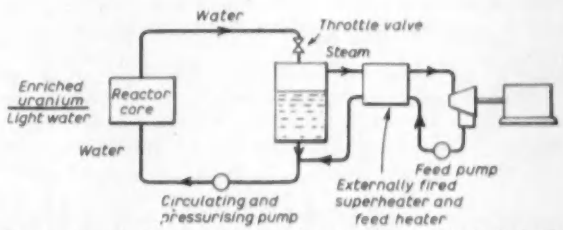


Fig. 4. Instead of a normal heat exchanger, steam can be flashed off

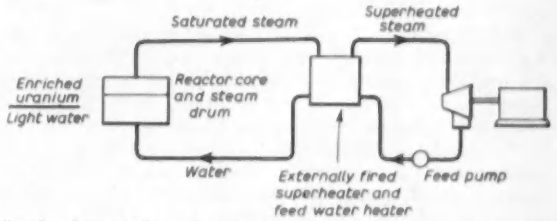


Fig. 5. Direct boiling of water is possible, giving low-pressure reactor operation

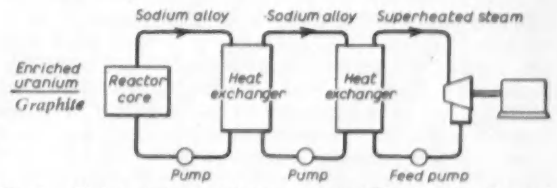


Fig. 6. Higher steam temperatures are possible if a liquid metal coolant is used. The moderator is graphite

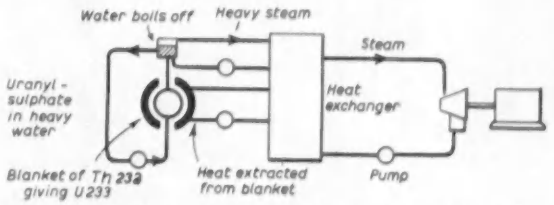


Fig. 7. In the homogeneous reactor the problems associated with "canning" fuel rods are avoided

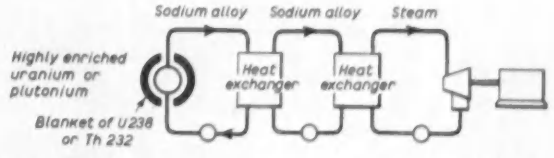


Fig. 8. The fast breeder reactor will produce more fissile fuel than it consumes as well as having a high heat rating

uranyl sulphate, dissolved in heavy water as the moderator. The heavy water boils off to give steam for turbines.

Advantages. Chemical processing costs are reduced, and a high heat output is obtainable, this being determined by the speed of fissile fuel circulation. Actual reactor structure is relatively simple. Some breeding is obtained in a thorium blanket placed around the reactor. Automatic control of reactivity is obtained because expansion ejects some of the fuel from the reactor as temperature rises.

Disadvantages. Only part of the uranium—that within the reactor—is contributing to power production at any one time. Because of delayed neutrons, the external system will become radioactive. Somewhat higher enrichment of uranium is required than with a heterogeneous reactor.

Fast Breeder Reactor (Fig. 8)

IF more fuel is to be produced than is used up a fast breeder reactor is necessary. In such a reactor highly enriched fuel is used, and there is no moderator. The result is an active core of very small volume—a cylinder of 2 ft in diameter and length has been mentioned with a heat rating of 100 MW. Control is by means of a blanket of U238 or Th232, which acts as a reflector and is moved with respect to the reactor core. Breeding of the fuels Pu239 or U233 takes place in the cores.

Advantages. More fuel produced than consumed. High temperatures, with consequent better steam conditions. Poisoning of plant due to build-up of fission products is less serious than with thermal reactors. This eases the control problem.

Disadvantages. Minimum amount of fissionable material has been put at 10-100 times that required for a thermal reactor. Control is cumbersome, and must be very rapid. Dual heat exchangers are needed because of sodium/water reaction. The whole heat-transfer problem is of the greatest complexity because of the high thermal fluxes and the low volume of the source.

REACTOR CONTROL PROBLEMS

Some Factors that affect operation of a Thermal Reactor

CLOSE control of nuclear reactors is necessary at all times. It requires only a slight excess reactivity for the neutron population of the reactor to increase enormously, with a corresponding increase in the rate of heat generation. Control in such cases is pre-eminently a matter for automatic equipment, and a great deal of work has been carried out in this field. The purpose of this article is to summarise briefly the main factors of importance in reactor control.

In a thermal reactor of the graphite moderated type, control is effected by rods containing a material of high neutron absorption cross-section. At the Windscale factory, for instance, the rods are of steel filled with boron carbide. Cadmium is an alternative to boron. When these are inserted into the reactor core, they at once reduce the reactivity. Normally, a reactor has a certain positive reactivity to overcome such effects as fission fragment poisons; and so the rods are some way into the reactor core even during equilibrium operation.

Delayed Neutrons

Even with automatic equipment, it would be difficult to maintain a reactor fully under control were it not for the phenomena of delayed neutrons. Most neutrons are emitted at the instant of fission, but with U235, about 0·76% of the total result from the radioactive decay of certain fission fragments. If the positive reactivity of the reactor is made entirely dependent on these delayed neutrons, then there is sufficient time lag to allow movement of the control rods to be effective if reactivity increases for some reason.

In addition to the gradually moved control rods, the reactor is equipped with emergency rods whose position is either full-in or full-out. These are arranged to shut down the reactor rapidly if anything appears to be going wrong.

If the control rods were left in one position for a long time, the output of the reactor would gradually decrease. This is mainly the result of three important effects—fuel depletion, poisoning, and the negative temperature coefficient of the reactor.

Fuel depletion occurs relatively slowly, the fissile material (U235) burnt up being partly replaced by further fissile material (Pa239) bred from the non-fissile U238.

Poisoning results from the formation of fission fragments having a high neutron capture cross-section. Xenon 135 is the outstanding instance of this. It is formed as a result of radioactive decay of tellurium 135 to iodine 135 and then to xenon 135, the half-lives for these steps being 2 minutes and 6·7 hours respectively. Thereafter, the xenon 135 decays to caesium 135 with a half-life of 9·2 hours unless it captures a neutron to form xenon 136. The time-delays imposed by these changes have a marked effect on reactor control when the operating power level is changed. In particular, if the reactor is shut down for a while, xenon 135 builds up, since there are no neutrons available for the capture mechanism to transform it to xenon 136, and the decay half-life is longer than the iodine 135 decay half-life. Thus extra reactivity may be required to counteract this effect if the reactor is to be capable of starting-up quickly after being shut down.

When temperature of the pile rises, certain physical constants such as the density of the uranium and graphite change, and the energy of a thermal neutron is, by definition, altered, and with it the cross-sections for the various neutron reactions. With some types of reactor, all these changes have the effect of decreasing the reactivity as the temperature increases.

Starting-up

In starting up a reactor, control rods must not be withdrawn to an extent that will allow the reactor to become too supercritical. To some extent, the problem is one of measurement, for if the actual neutron conditions within the reactor are known, appropriate steps can be taken to adjust the speed of control rod withdrawal. Very safe methods of starting-up are liable to be very slow methods, especially after a complete shut-down.

It has been suggested that control rod systems should be divided into two parts. One set of rods (control) would be designed to absorb all the built-in reactivity of the reactor, but would be slow-acting. They would be used in conjunction with another set of rods (regulating), quick-acting, but absorbing only a limiting amount of reactivity. Control rods would move steadily in an attempt to keep regulating rods in a mid-position. Regulating rods would react quickly to changes in conditions.

A Nuclear Glossary

Definitions of some terms used in Nuclear Engineering

MOST branches of technology have their own terminology. Nuclear engineering is no exception. Many of the terms it uses are taken from the language of the physicist, but to an increasing degree terms are coming into use which have a meaning specific to nuclear engineering. The more important terms are listed below, and amongst them will be found definitions of most of the names and units used in preceding pages of this special section, which may have been strange to electrical engineers.

Binding energy. When elementary particles such as protons and neutrons come together to form the nucleus of an atom it is found that the mass of the nucleus is less than the sum of its constituent particles. This deficiency in mass is equivalent (from Einstein's work) to a certain amount of energy, and this equivalent value is the binding energy. The actual value varies with each substance, and if average binding energy/particle is plotted against mass number, the curve is found to peak at about 70 and then fall slowly and steadily as mass number increases. Thus when U235 fissions into neutrons and fission products with masses centred on the value 118, the total binding energy of the products exceeds that of the original U235: i.e. some energy must be released, because mass has been lost. This is the energy which gives useful heat in a nuclear reactor.

Breeding. It is possible to prepare fissile materials from certain non-fissile materials by bombarding them with neutrons. This is known as breeding. Even in the thermal reactor some breeding occurs due to the formation of plutonium from the non-fissile U238, but over a period less atoms of plutonium are formed than there are atoms of U235 fissioned to keep the chain reaction going. There are in prospect fast reactors (see page 168) in which more fissionable material will be produced than will be used up in sustaining the chain reaction.

Critical Size. Applied to a reactor, critical size is the smallest assembly of fuel elements and moderator which will sustain a chain reaction. If a reactor is below the critical size, the external area through which neutrons may escape is too great with respect to the volume of the reactor, in which fission may occur.

Cross-Section. The chance of a collision between a bombarding particle and the nucleus of an atom varies according to many factors. The usual way of expressing this probability is to quote the "cross-section" for a particular reaction. This is the effective area presented by the single target nucleus to the bombarding particles under defined conditions and for a given result. Because of the effect of electrical and other forces near the nucleus, the reaction cross-section is not necessarily the same as the geometrical cross-section of the nucleus, though it is often of the same order of magnitude. Nuclear cross-sections are usually measured in units of 10^{-24} sq cm, which unit is known as a barn. The cross-section for fission capture of a neutron by U235 at thermal speeds (about 1 mile/second), for example, is 549 barns, whereas at fast neutron speeds it approaches 0·29.

Electron-volt. The measure of energy adopted for radioactive particles. Equal to the energy gained by an electron in being accelerated through a potential of one volt, usually expressed in MeV (mega-electron volt) for fission fragments, etc. 1 MeV = $1{\cdot}6 \times 10^{-6}$ ergs = $1{\cdot}6 \times 10^{-13}$ watt-seconds.

Enrichment. Naturally occurring uranium consists of a mixture of two isotopes, U235 and U238, in the ratio of about 1:140. Only the U235 is a fissile material, and for some designs of reactor, it is too "diluted" in this form. To adjust the concentration nearer to the required level, some of the U238 may be separated out by physical means, or else Pu239, another fissile material, may be added. This process is known as enrichment.

Fertile Material. There are two isotopes of uranium and thorium which under neutron bombardment will be transformed into fissile fuels. These are called fertile materials, and they are U238 (giving plutonium 239) and Thorium 232 (giving U233).

Fissile Material. A material which will undergo fission when bombarded with neutrons. Examples are Pu 239, U233 and U235.

Fission. Fission is the name given to the break-up of the nucleus of an atom due to its becoming unstable. There is a great number of possible fission reactions. The nucleus in such a case usually gives off various particles and fission products. Usually there are two or more fragments resulting from fission, together with the emission of neutrons, electrons, and much energy. Uranium 235 can break up in about 30 possible ways. Most of the fragments are concentrated in two groups, with mass numbers around 90 and 140.

Fission Fragments. When fission occurs, the fissile material breaks into particles, have aggregate mass numbers equal to that of the fissile nucleus plus the incident neutron. There are usually two major constituents amongst these fragments, having mass numbers centring on about 120—e.g. Krypton 92 and Barium 142 for one possible form of fission of U235. The fission fragments themselves may undergo radioactive decay.

Half-life. The time taken for the activity of a radioactive substance to decay to half its original value, that is, for half the atoms to disintegrate. The usual way of indicating the speed of this decay is to give the half-life, because the decay itself varies according to an exponential law, i.e., rate of disintegration at any given time is proportional to the number of radioactive atoms then present. Average life is about 1·4 times the half-life.

Heat Rating. The rate at which fissile fuel is "burned" in a reactor is expressed in terms of the output of heat, usually megawatts per metric tonne of fuel.

Heavy Water. Hydrogen has an isotope of mass number 2, usually called deuterium (or heavy hydrogen). Water containing a high proportion of this isotope in place of ordinary hydrogen makes an excellent moderator, having a particularly low cross-section for the capture of thermal neutrons. Heavy water can be separated from ordinary water by physical means, but the process makes it very expensive—35 times the price of whisky has been quoted.

Isotope. There are about 98 chemically distiguishable elements, each of which has its own chemical properties. Most elements, however, occur with two or more mass numbers. Each mass number represents a different isotope

of the element, and isotopes have slightly differing physical as distinct from chemical properties.

Mass Number. The total number of particles (neutrons and protons) in the nucleus of an atom. Mass numbers vary from 1 (hydrogen) to 238 (uranium) for elements which occur in nature. It is the mass number which is written in familiar statements like U235, U238, Pu239.

Moderator. In most designs of reactor, the neutrons have to be slowed down to thermal speeds (a mile a second or so) before they can cause fission. For this purpose a moderator composed of elements of fairly light atomic weight is incorporated in the reactor. The principle is that the neutron shall gradually lose energy by repeated collisions with the nuclei of the moderator materials. Relatively light nuclei are necessary if energy is to be lost at a reasonable rate. It is also necessary, however, that the moderator materials should have a low cross-section for the capture of thermal neutrons. Of the elements up to oxygen (eighth in order of atomic number) lithium, boron and nitrogen are unsuitable because of their relatively high capture cross-sections. Helium, being an inert gas, cannot be obtained in some solid or liquid compound form. This leaves hydrogen, beryllium, carbon and oxygen. Hydrogen and oxygen in the form of heavy water or ordinary water are satisfactory for reactors of medium size. The usual choice for very large reactors, such as those being built first in the British nuclear power programme, is carbon in the form of graphite.

Neutron. An elementary particle of about the same size and weight as a proton, but having no electrical charge. It can thus penetrate relatively easily into the neucleus of an atom.

Neutrons are referred to by various terms in reactor technology. *Fast neutrons* are those travelling at very high speeds immediately after being ejected from a fissioned nucleus. (Speed about 6,000 miles/second, energy 1—2 MeV.) *Thermal neutrons* have been brought into kinetic equilibrium with other particles according to the temperature (0·025eV at room temperature; speed about 1 mile/second.) *Prompt neutrons* are those given off immediately on fission. *Delayed neutrons* are the small proportion (less than 1%) of neutrons resulting from fission, which appear as the result of radioactive decay of some of the fission fragments. These delayed neutrons are most important in reactor control.

Nucleus. The central part of an atom, built up of protons and neutrons. Most of the mass of the atom is centred here, and the number of protons determines the positive charge of the nucleus, and thus its chemical properties (which element it is). There can be different numbers of neutrons in the nucleus for a given number of protons, and this possibility gives rise to the existence of isotopes.

Particles—Alpha, Beta and Gamma. Radioactivity manifests itself in the discharge of various detectable radiations from the radioactive material. The more common particles are:

alpha—identical with the helium nucleus of two protons and two neutrons.

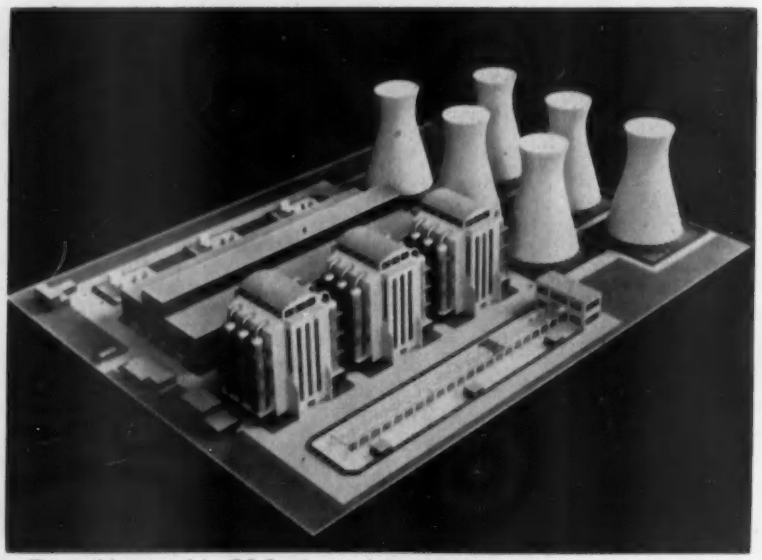
beta—an electron, usually high speed. May sometimes be a positive electron.

gamma—electro-magnetic radiation similar to X-rays. These "particles" differ from alpha and beta particles by not being affected by electro-magnetic or electrostatic fields.

Poisons. Some fission fragments have a large cross-section for the capture of neutrons, and tend to slow down or stop the chain reaction. The outstanding example is xenon, which has a cross-section for the capture of thermal neutrons of 3,500,000 barns (c.p. 549 barns for the fission of U235 by thermal neutrons).

Proton. The nucleus of a hydrogen atom, which is 1,840 times the mass of an electron. Carries unit positive charge.

Reactivity. Reactivity is the excess of neutrons in a reactor in any generation over those in the generation before. Consider a chain reaction proceeding at any instant. A certain number of neutrons have survived from previous fissions and are about to cause a new set of fissions. The cycle—or generation—is complete when a proportion of the neutrons released as a result of this event are themselves about to cause yet another set of fissions. When reactivity is zero, the reactor is said to be *critical*. When it is positive, so that there are extra neutrons in each generation the reactor is said to be *divergent*. When reactivity is negative, with successively fewer neutrons in each generation, the reactor is termed *convergent* or subcritical. Reactivity is usually expressed as a percentage.



This model prepared by G.E.C., gives an impression of a possible nuclear power station using gas cooling under pressure. It has three reactors each with six heat-exchangers

Reactor. Reactor is the general term used for the assemblage in which heat is generated by nuclear fission. Where heat is not intentionally produced, the term "pile" is sometimes substituted. There are two main classifications of reactors—heterogeneous and homogeneous; and fast, intermediate or slow. The first of these classifications refers to the fuel/moderator arrangement. Most reactor designs are *heterogeneous*, the moderator and the fuel being kept quite separate. In *homogeneous* reactors the two are intimately mixed in solution or slurry form.

The fast, intermediate and slow classification refers to neutron speeds (see under neutron). *Slow* is a synonym for thermal. *Intermediate* means what it says, and is used for reactors in which neutrons are slowed to a particular speed at which cross-sections for fission show a resonance. *Fast* reactors make use of fast neutrons which have not been slowed down after production in fission.

From an engineer's notebook

WHEN I was a boy, I was told at school that diamonds were carbon, crystallised under high temperatures and pressure and small gems had been synthesised in the laboratory by such means. With this background I must confess to no surprise when the G.E. of America announced the production of diamonds in their research laboratory. Now that further information has become available it would seem that serious doubt is thrown on some of the earlier claims for the production of diamonds, since diamond formation is now known to require pressures and temperatures most difficult of attainment. Indeed it seems to me that the achievement of the G.E. laboratories is not so much the production of diamonds, but in the design and construction of equipment capable of giving them the ultra high pressures required. Surprisingly, a simple piston and cylinder arrangement was adopted but since the effect of increasing wall thickness beyond a certain limit adds little to its ability to hold pressure, alternative means of construction had to be used. On the actual design, information is unfortunately not available, it is merely stated that new ways were developed for distributing stress and giving support to critical parts. The result, however, is a claim to operate continuously at pressures up to 1,500 klb/sq in. with temperatures over 2,000° C, truly surprising figures. With this equipment the manufacture of diamonds is a repeatable operation and sizes up to one quarter carat are obtained. The greatest care has been taken to ensure that these products are true diamonds by comparative tests of distinctive characteristics. In addition to tests for hardness and for chemical analysis, a study of X-ray diffraction patterns showed that they matched those of natural diamonds and the refraction index was checked. All of which makes one wonder whether diamonds are so readily identifiable as jewellers lead us to believe.

* * *

IN the days when I was interested in engagement rings, I learned that there were several kinds of diamonds. These have now been scientifically classified (but not from the jeweller's point of view), and it has recently been discovered that the type IIb (do not ask me what the designation means) which embraces all blue diamonds, has semi-conducting properties. Exactly why this should be is uncertain, since it does not appear to be due to the unsatisfied valency bonds caused by the presence of an impurity and it is suggested that the explanation may lie in some type of crystal imperfection since it is known that lattice disorder may produce p-type conductivity in other materials. Like other semi-conductors diamond is temperature sensitive and it appears necessary to operate at a value above ambient for the best results. Such diamonds offer at least some promise as rectifiers, since at temperatures of 200° C, with a pressure of 5 V, tests showed a forward current of 100 microamps with nil reverse current. More unusual is the statement that some diamonds can carry currents of the order of ten amps at 125 V, but such a value suggests some factor in the behaviour of the crystal that has yet to be determined. Clearly there is much work to be done before the commercial possibilities of diamond as a semiconductor can be assessed, but is there here a semblance of the much-needed high-rated static rectifier? However, even with the new manufacturing technique that is now available for diamond extended far beyond its present stage of development, it seems unlikely that the same control of crystal structure will be achieved as that available with germanium or perhaps the less tractable silicon.

* * *

THE sea is the traditional home of mysteries and if, in this scientific age, we have become sceptical of the sea serpents of the past, it is only right and proper that we should have our own, more abstruse, mystery to cogitate upon. What more exciting to an electronic age than reports that under certain circumstances phosphorescence has been seen, the origin of which appears to be radar. Several accounts have been given of this phenomenon but unfortunately the characteristics reported by different eye witnesses appear to differ somewhat, very much as did those of the sea serpent. Some reports speak of flashing lights which faded when the radar transmission was switched off and reappeared when scanning was resumed. Others speak of patches of light and one account goes so far as to state that the area of fluorescence was shown up on the radar screen. The sea has so many scientific variables that one would hardly expect uniformity of reports and much wider experience will be necessary before a clue can be found to the solution of this apparently impossible phenomenon.

* * *

THE reduction of eddy currents is largely a matter of using sufficiently thin laminations and if the size can be taken down to atomic thinness this form of loss can be eliminated. Such is the aim in a new technique of magnet manufacture, which is also said to improve control over the hysteresis loop. This process uses a vacuum coating technique in order to obtain the necessary thinness of film which is deposited on a plastic or glazed base. In production this base is held above a crucible containing the alloy which is heated by h.f. induction, the whole being contained within a vacuum chamber. Having deposited a metal film, interlayer insulation is applied by a similar method of coating and in this way with successive operations, a multi-layer magnet can be built up. It is reported that the most satisfactory results were obtained with an 80% Ni 20% Fe alloy with magnesium fluoride as the evaporated dielectric. While one naturally appreciates the advantages of such a multi-layer magnet, one can only speculate as to whether the cost will ever permit this method to emerge from the laboratory. *E. R. G.*

READERS' VIEWS

Correspondents writing under a pseudonym are asked to submit their names in confidence to the Editor

Spare Time Work

WITH reference to "Full Timer's" letter concerning spare-time work, I think I am in a position to answer most of his questions, being in an area that is rife with spare-time work and casual employment.

I am fully in agreement with "Full Timer" that the shorter working week was negotiated with the full intention that it would rest the workman and give him more time to devote to his family, social and sporting life, and assist in abolishing the spectre of unemployment. It is, however, known that at the local power station several employees have employment outside their normal working hours, working for local nurserymen, in factories and as jobbing gardeners and arrange these spare-time jobs according to the shift rotations of their normal employment. On the electricity board, employees working evenings and week-ends at nurseries, cinemas, etc., are plentiful. This does not, however, just appertain to the supply industry alone, it is also rife in all the trades, especially where shift work is in being, notably railways, gas works, bus companies, etc. It may possibly be a pointer to some of the rail accidents of later years. Management has no authority in the matter, as, providing a workman turns up and does his time, no management can object to such practices. I know one man who works normal hours and does telephonist work at night.

All these grabbers work for cut-price wages to the detriment of the agricultural workers, etc., and would, and do, squeal like pigs if their normal wages were touched, or they were asked to do a job of work other than their normal one. This is a problem purely for the Trade Unions alone, not for management. I have heard the problem debated and deplored several times at the local branch meetings, yet beyond that nothing is done. The Unions are too afraid of losing membership: that is why their heads are buried in the sand. None must abuse their trade, but any Tom, Dick or Harry, can cut-throat the other bloke's trade. Let the Unions get moving and compel their members to work for the full rate at all trades and work the shorter working week as was intended, and compel their members to acknowledge the other workman also. Any member found to be working under the rate, cut-price at any form of work, spare-time or normal, should have the Unions fall on his or her neck like a ton of bricks. Spare-time working for cut-price wages is a vile practice and smells, and makes the Unions smell also. It is surprising, considering the number of decent minded men and women who abhor them, how such practices came into being. They are prevalent through the whole of the country. As "Full Timer" remarks it is a post-war evil, and a pointer it may be. A decent tradesman does not belittle himself nor his craft.

"Unionist."
ESSEX.

Wiring in Australia

I HAVE read with some interest the article which appeared in the ELECTRICAL TIMES of the 10th March, 1955, headed "Wiring in Australia—Techniques down under seen through English eyes." There are, however, certain aspects of this article which may present a somewhat incorrect picture of Australian wiring practices and I am, therefore, submitting additional information herein to adjust any incorrect impressions that may have been gained.

In the first place it is important to note a fundamental difference in Australian and English practices as related to the Australian S.A.A. Wiring Rules and the I.E.E. Wiring Regulations respectively. This arises from the fact that in most States of Australia the S.A.A. Wiring Rules have legal standing in that they constitute the minimum legal requirements with which installations must conform. In those States, supply authorities are required to inspect installations upon completion and the Inspector must not connect the installation if he finds that it does not comply with the requirements of the S.A.A. Wiring Rules in any particular. It is understood that the I.E.E. Wiring Regulations do not have similar legal force.

This aspect places the S.A.A. Wiring Rules and the I.E.E. Regulations on an entirely different footing. As I understand it, the I.E.E. Regulations constitute, in effect, a code of good practice and an installation which conforms with those Regulations will be of high standard. The S.A.A. Wiring Rules, on the other hand, being minimum legal requirements, are purported to enumerate only the essential requirements and precautions for ensuring satisfactory results, including safety from fire and shock. An installation carried out merely to the requirements of the S.A.A. Wiring Rules, therefore, although it should be safe, need not necessarily be of high quality, and if an architect or owner requires a high-quality installation it is customary for him to specify additional requirements over and above those of the S.A.A. Wiring Rules. Upon consideration it will, I think, be agreed that if a code of wiring rules is set up as a minimum legal standard, then requirements exceeding the minimum for safety and satisfactory operation could hardly be justified. It is, I think, true to say that the vast majority of installations in Australia are carried out to standards in excess of those called for by the Rules.

Dealing now with certain detailed criticisms that appeared in the previous article, the following comments from one who, in addition to having many years experience in installation matters, has for some years been associated with the preparation of the S.A.A. Wiring Rules, may be of interest.

Your correspondent refers to the fact that the S.A.A. Wiring Rules allow up to 15 socket-outlets in domestic installations to be connected to a final sub-circuit wired with 1/·064 or 3/·036 cables and draws an alarming picture of the overloads that may occur if certain combinations of appliances are used at the same time. Before this rule was introduced the Rules permitted only four such outlets to be connected to a circuit protected by fuses. The Electricity Supply Association of Australia carried out many hundreds of tests in all parts of Australia and under widely varying climatic conditions, of the maximum demand created by the socket outlets in domestic installations. These tests produced some interesting results, namely, that only in an insignificant number of cases did the maximum demand created by the use of all the socket-outlets in any one premises exceed 15 amps and further, that this result was quite independent of the number of

outlets installed. In point of fact most of the cases where a demand of more than 15 amps was registered occurred in premises in which only two or three outlets were installed. The conclusions drawn from this were, firstly, that the actual demand created by the use of socket-outlets in domestic premises is virtually independent of the number of outlets installed and that above two or three outlets the provision of additional socket-outlets serves only for added convenience rather than as providing additional load; and secondly, that a considerable diversity existed between the use of various appliances. Radiators appeared to be the dominant factor in creating the demand and, in this connection, when radiators are in use the ambient temperature will generally be low and the cable can therefore carry a greater load without overheating.

The matter of permitting the installation of socket-outlets in bathrooms has been a contentious one, but there is some demand for such outlets for the use of electric shavers. The position is, perhaps, not as bad as it sounds because the S.A.A. Wiring Rules lay down fairly stringent provisions with regard to the position of these outlets and their spacing from basins, baths, etc.

With regard to switchboards, it is true that the general practice has been for the contractor to make up a switchboard for each particular job although the use of standard panels with fire proof metal enclosures for the wiring behind the panel has been common for many years. During the last few years there has been a tendency for manufacturers to produce factory-made standard switchboards which will cover a large variety of applications and this tendency is one to be encouraged as it undoubtedly results in better workmanship.

Regarding earthing, it is true that the M.E.N. system of earthing is more widely used than any other system although some large Supply Authorities still use the direct earthing system and this Council, with over 300,000 consumers, uses the earth leakage circuit-breaker system. With the M.E.N. system it is true that where a suitable metallic water supply system is not available at the consumer's premises the earthing system of the installation, in addition to being connected to the neutral link, is connected to a driven electrode. Such an electrode cannot, of course, be regarded as an effective earth if the neutral service wire were to break, but is installed rather to provide a large number of neutral-earth connections in parallel through the various consumers' installations. The possibility of a dangerous condition arising if a consumer's neutral service wire breaks is, of course, an admitted weakness of the M.E.N. system but in practice little or no trouble seems to arise from this cause.

Your correspondent quotes the S.A.A. Wiring Rules as laying down that the resistance between the consumer's earthing system and earth should not exceed 2 ohms for a new installation and 5 ohms for an old installation. This is not entirely correct. The rules which apply only to new installations and to additions, require that the earthing system and earthing resistance must be effective and that in any case the resistance to earth should not exceed 2 ohms. The Rules make no mention of the resistance to earth for old installations but the figure of 5 ohms is used by some supply authorities in checking old installations.

Again your correspondent is not entirely correct in stating that consumers' mains run in t.r.s. or p.v.c.-sheathed cables from the point of attachment of the overhead lines to the switchboard, may be run without further protection through roof spaces or down wall cavities. In point of fact, the Rules lay down that, subject to the approval of the supply authority, consumers' mains consisting of t.r.s. or thermoplastic sheathed cables, need not be enclosed in conduit or other protective covering where they are protected by fuses or where they are open to view. In other words, where these cables are not open to view, such as in a roof space or down a wall cavity, they must be enclosed in conduit unless they are protected by fuses. Generally, very little trouble seems to be experienced in this country with regard to theft of electricity.

Some mention is made of mixed circuits, that is to say circuits supplying both lighting and socket-outlets and it is true that limited used is made of such mixed circuits. There is, however, little likelihood of a house being wired completely with a mixed circuit and the number of points permitted on such mixed circuits is strictly limited. In particular, these mixed circuits have their application where it is desired to run wiring to a detached building such as a garage or workshop to supply, say, one or two lights and a socket outlet. In such cases the use of a mixed circuit avoids having to run two lots of wiring to the outbuilding.

Generally speaking, it is believed that the standard of wiring in Australia is reasonably high and certainly the number of accidents that can be attributed to poor wiring is very few. As in most countries, the majority of electrical accidents arise from ignorance or interference with appliances or installations. In comparing Australian and British wiring conditions it is important to keep in mind two factors. These are, firstly, that as pointed out above, the wiring requirements here are mandatory and therefore cover only minimum safety conditions and, secondly, that practically all consumers in Australia, other than in central city areas, are supplied through overhead services and not through underground cables This latter factor, of course, has a large bearing on the earthing systems employed.

H. S. Lloyd, B.E., A.M.I.E.E., A.M.I.E.(AUST.)
Chief Installation Inspector
SYDNEY COUNTY COUNCIL, AUSTRALIA.

Static from Floors

I WAS very interested in the remarks of your correspondent regarding static generated on certain types of floor surfaces. This might be a source of danger in such places as hospitals, where steps are taken to discharge static by means of a trailing chain on trolleys, etc. It could possibly happen that static might be picked up instead of discharged.

Regarding the use of conducting floor surfaces, this, too, can be a source of danger, particularly when the conducting surface is more or less insulated from the mass of earth. I am reminded of a fault which I was called to some time ago. The consumer complained of shocks from the water tap when using the electric kettle. On testing the kettle, it was found to be faulty to earth. I was still puzzled as to how this leakage could be felt in the water tap, and upon examining the lead of the kettle, I was surprised to find that it was of two-core flex, and that the case of the kettle was not connected to earth. However, I had a guide when the consumer stated that the shocks were more severe after she had washed the floor. This consisted of reinforced concrete built upon brick piers, so while the surface was a partial conductor when wet, the bricks (associated with the damp-course) partially insulated it from the ground. Also the kettle was used upon a modern type of steel table. It was, of course, the floor which was becoming alive, from the kettle, via the steel table. The shocks were only felt when the circuit was completed via the water tap, thus giving the effect of the taps being alive.

W. T. Wedlake,
PORTH, RHONDDA.

Higher Stresses in Oil-Filled Cable

New Three-Core 132 kV Design passes Tests

THREE-CORE 132 kV oil-filled cables have recently passed a stringent test schedule at the Research Laboratories of W. T. Henley's. Single-core 132 kV oil-filled cables have been operating in London for more than 20 years, but using previously established dielectric stressing, 66 kV has so far been the highest voltage for 3-core oil-filled cables. The new step in design has resulted largely from research into materials and processing methods.

An important step in production of the new design, as far as W. T. Henley's were concerned, was the installation recently completed for the City of Belfast, comprising two

Fig. 1. Use of this dividing box when cable tails are 30 ft or less in length avoids disturbance of factory-applied insulation

3-mile, 0·3 sq in., 3-core, 110 kV oil-filled cable feeders, each capable of transmitting 75 MVA. The maximum working stress in the dielectric of these cables is 85 kV/cm, and the test performance on the cables included a loading cycle test of twenty daily heat cycles with conductors at temperatures up to 90° C, and continuous superimposed voltage of 127 kV. The results obtained on this design suggest that a similar design of 132 kV cable could be produced, operated at a higher stress and having an adequate margin over specified impulse voltage withstand values.

132 kV Design

The result has been designed for a 3-core, 132 kV, 0·2 sq in. conductor with a designed maximum stress on the conductor surface of 100 kV/cm. In this design, the thickness of the dielectric is 0·515 in., and the lead sheath thickness 0·125 in. Conductors are screened by means of semi-conducting paper.

Joints are a crucial factor in any successful cable installation, and much development work has been put into these accessories in the new cable. For a straight-through joint, a design incorporating paper rolls has been produced having a length and diameter only one and a half times those of the corresponding joint used in the single-core cable of the same conductor size. A similar construction is used for trifurcating joints where length of the single-core tail required must be greater than about 30 ft. Where tails are shorter than 30 ft, however, an ingenious method has been found of disposing of the trifurcating joint. A dividing box which is relatively small (see Fig. 1) is used, the three individual cores of the 3-core cable being passed through the box and into reinforced lead tubes, to produce the single-core tails. With this procedure factory-applied insulation is not disturbed and there is no joint in the general sense of the term.

The tests to which the new design has been subjected were carried out on a system consisting of six sealing ends, one straight through joint, one trifurcating joint, and one dividing box. An interesting point of test technique was the use of ring-type transformers to provide heating current, the individual cores of the cable being short-circuited (see Fig. 2). The system was heated to a conductor temperature of 85° C and each core was subjected to impulse tests while operating at this temperature. The required withstand voltage of 640 kV peak, with a 1·6/50 wave was met with what has been described as an ample margin. Loading tests were carried out with superimposed voltage 150% of working voltage, with a programme of 20 heat cycles of six hours heat and eighteen hours cooling. Original tests were performed with a conductor temperature of 90° C, but in view of the good stability as shown by the power factor tests, the temperature was raised in steps to 120° C, still with no indication of instability. Similarly, mechanical tests generally on a line with British Standards requirements have been passed successfully.

The company has recently obtained a contract for manufacture and installation of 132 kV, 3-core, oil-filled cables for the North West, Merseyside and North Wales division of the C.E.A. The installation will consist of three cables, each capable of transmitting 70 MVA, linking the Agecroft (Manchester) power station to a new supply point at Bloom Street, Manchester.

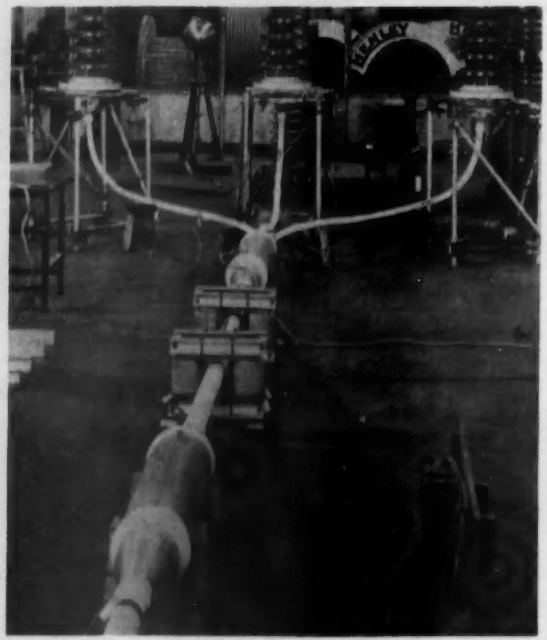


Fig. 2. General view of test installation at Henley's Research Laboratories, Gravesend. Note ring-type transformers for inducing heating current in cable cores. A straight-through joint is in the foreground

PROBLEMS AND PRACTICE

In Engineering

Every engineer has a story to tell; why not tell yours on this page? We welcome contributions to this feature, and those published will be paid for at our standard rates. Problems which are encountered and overcome in day-to-day maintenance or installation of electrical plant; useful methods and techniques developed for specific jobs, or current practices, all make instructive reading for others. We will also consider for publication problems requiring an answer. Sketches are often helpful and need only be rough, as they will be redrawn before use.

Hot Bearing

SOME time ago I was called upon to undertake the overhaul of some electrical equipment in the power house of a large factory, during the annual holiday period. Included in the generation was a d.c. generator of around 1,000 A capacity driven by a high-speed steam engine, direct-coupled on one bedplate, and the overhaul of the engine was carried out by the manufacturers outfitter, an engineer of the old school with 50 years' experience. One of the items down for particular attention was the commutator end bearing of the machine, we were informed that despite the skilled attention of the engineering department, who could find no fault with it, the bearing had for some months grown increasingly hot.

The old fitter examined the bearing closely and pronounced it to be in good condition. I also agreed with him and, indeed, would have hesitated to do otherwise in view of his wide experience.

Later in the day he sought me out and asked if it was possible for any electricity to be present in the bearing. After assuring him that the insulation was perfect, I asked what was in his mind and he told me that many years ago he, as a boy, had heard other engineers discussing a case of a hot bearing and to the best of his recollection the cause had been found to be electricity. I was about to dismiss the whole thing as somewhat fanciful when it occurred to me that what the old man meant by electricity was perhaps more correctly, magnetism. I returned to the machine and found that the shaft and pedestal were indeed magnetised, the degree of magnetisation being such that the shaft would support a 6 in. steel rule with ease.

The problem now was to de-magnetise the affected parts and I accomplished this by means of odd pieces of iron bar, two or three coils of v.r.i. cable, a supply of a.c. and a fair amount of experiment. The pedestal presented the worst problem, one corner of the faced half being particularly stubborn. Eventually, however, the job was completed and we stood by for a test, the engine was completed on the fifth day and ran under full load for ten hours. To our great satisfaction the bearing reached normal temperature and remained there throughout the run and so far as my knowledge goes has given no trouble since.

I am at a loss to know how the shaft became magnetised, but I suppose that, once magnetised, its rotation set up eddy currents in the brass of the bearing, with consequent heating up. Perhaps readers with a similar experience may have an alternative explanation of this occurrence to offer.—*H. Holland.*

Movable Bench Fitting

I SUPPOSE electrical purists will find something to complain about in the bench light arrangement illustrated, but in the absence of anything of equal efficiency for getting light at any part of a long bench, we have adopted it with considerable benefit in engineering production and maintenance work.

The lamp, with shade and switch, is suspended from a simple curtain runner which slides on a tight supporting wire strung over the bench. The flexible cord is divided up into a series of loops which are also anchored to curtain runners. The supporting wire can be up to 12 ft long

Suggested method of suspending a fitting over a long bench to enable any part of it to be lighted

so that the lamp may be moved along a bench or machine tool for this distance. Height adjustment for the lamp is provided by a piece of plywood having holes drilled through it to take the flex; the holes in the wood lock themselves automatically on to the flex securing the lamp at any desired height setting, although it will, of course, be necessary to remove any sharp edges on the holes to ensure that the cord insulation is not damaged.

One of the main advantages of the arrangement is that a large shade with an efficient spread of illumination can be used, unlike many of the adjustable arm fittings which have small shades and small lamps. In the absence of a convenient wall at the bench end for anchoring the supporting wire, arrangements can be made to provide horizontal arms projecting from a rear wall or from upright angle brackets bolted to the back of the bench.—*C. T. Bower.*

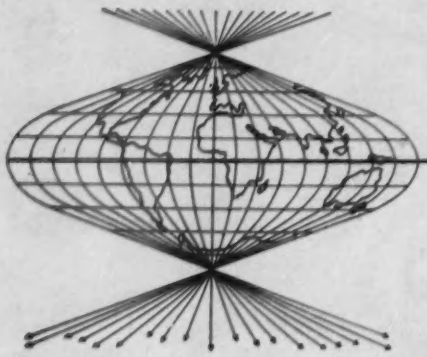
"Faulty" Radio

A RECENT experience illustrates the susceptibility of radio receivers to electrical faults. I had been instructed to collect for repair a receiver alleged to be noisy and suffering from crackle. However, to assure myself that it was the receiver at fault, I switched on the set on arrival at the premises. I noted that the receiver was supplied from a 5 A, three-pin switched socket-outlet, in which a "multiplug" was in use to supply a non-automatic electric iron from the same point. The receiver earth had been connected to the earth tube of the "multiplug" outlet in use.

On hearing that the interference was at its worst when the iron was in use, an inspection of this appliance seemed necessary, but no fault could be discerned. In verification of the lady's statement, I also switched on the iron, and obtained the increased crackle on the receiver.

Inspection of socket-outlet revealed nothing amiss, but operation of both receiver and iron from an outlet in the next room resulted in complete disappearance of the crackle. Obviously, it was not the receiver which was at fault. A "Megger" insulation test of the circuit normally used indicated low resistance to earth, and as the socket-outlet was quite close to the main switchfuse, I decided it would be more satisfactory to rewire this circuit before investigating further.

Removal of floorboards, however, disclosed a join in the lead covered cable supplying the outlet — an "amateur's" work to move the outlet to its present position from one nearer the switchfuse—and that not only had the join been insulated with insulating tape but the two sections of lead sheath had been left unbonded. The point at which the conductors emerged from the sheath of the extension showed definite signs of "earthing" of the live conductor, and as the joint itself was lying against an outside wall, which, due to the house being considerably old, was wet, it seemed likely that leakage to earth via the wall had been taking place. Correct rewiring of the circuit with a single length of cable removed the crackle from the receiver, and left me wondering how many "repairs" are effected to "faulty" radio receivers when the trouble really lies in the wiring.—*J. H. Robinson.*



OVERSEAS NEWS

A SUMMARY OF IMPORTANT EVENTS

CANADA

More Water Storage

Objections to the British Columbia Power Commission's proposals to build a storage dam on Upper Campbell Lake have been dismissed by the Provincial Comptroller of Water Rights. The Commission, therefore, proposes to call immediately for tenders for the $19m project. The first phase, calling for a 79 ft high storage dam on Upper Campbell Lake, may be completed next year. The second stage will be another 30 ft to the dam, raise Upper Campbell Lake a further 30 ft and Buttle Lake 15 ft. This scheme will, in effect, create one long lake out of the two.

Line Work

A 106-mile power line from Weyburn to Regina and Moose Jaw, to operate at 144 kV, will be the longest the Saskatchewan Power Corporation will build this year in its construction programme. The Corporation also plans to complete a 72 kV line from Estevan to Yorkton, and to build a similar line from North Battleford to Glaslyn. The latter line will operate at 25 kV initially.

Funds for Development

The Manitoba Hydro-Electric Board estimates its financial needs within the next six years will require bond issues totalling some $127m. This sum will cover the construction costs of the steam power station at Brandon, and the proposed new hydro-electric station at Grand Rapids, to which we have already referred. The board has already issued several bond series. The capital investment of the board was $72,462,477·28 as at 31 Mar., 1955, and this was financed in part by advances from the provincial government and latterly by the board issuing its own bonds to finance development.

MEXICO

Power Expansion

Further extension of power generating facilities in Mexico are announced, in addition to those of the Mexican Light and Power Co., to which we referred on 14 July. This is a five-year programme, estimated to cost 500 million pesos, of the Compania Impulsora de Empresas Electricas, involving 88,500 kW of plant. This concern's plans include a 30 MW thermal set for Celaya, in the State of Guanajuato, a similar size unit for the system supplying Torreon and Chihuahua, a 4,500 kW hydro-electric set for El Platanal power station in the State of Michoacan, an additional 12,000 kW machine for the station near Puebla, a 7,000 kW thermal set for Tampico and a 5,000 kW machine for Merida, State of Yucatan.

SOUTH AMERICA

Local Manufacture?

There is likelihood that Brazil may set up its own heavy mechanical and electrical manufacturing industries it seems. The President of the Republic has nominated a Working Group to consider the matter, the principle aim being to manufacture equipment locally for the petroleum industry, but the question of the associated electrical equipment is also to be studied, we understand.

Railway Scheme

It is proposed to modernise Buenos Aires city and suburban and underground railway systems. The director of planning, of the Argentine Ministry of Transport, has stated that work is shortly to be undertaken, the whole cost being estimated at 3,100 million pesos. The work proposed involves an extension of the underground system, the electrification of suburban services, the removal of the terminal goods stations to outside the city limits, and the elimination of level crossings. We gather that the plans for the scheme have been drawn up for some time, and were based on preliminary work undertaken when the railways were under British management.

Quite recently the Ministry of Transport purchased a number of diesel-electric multiple unit trains from Japan.

SCANDINAVIA

Tax Abolition Sought

The Federation of Swedish Industries has asked the Committee on Indirect Taxation to propose to the Swedish Government the abolition of the electricity tax as soon as possible. The Federation motivates its proposal by the fact that production costs in Sweden have gone up considerably during the last few months and exceed increasingly the level of costs in other countries competing with Sweden in export markets. This tax is claimed to be a heavy burden on all exporting industries, in particular the electro-chemical and electrical machinery concerns.

The Finnish Touch

Agreement has been reached between the Finnish Voima Oy engineering company of Imatra, and the Soviet firm Teknoexport, under which the Finnish company will investigate the possibilities of building a power station near the Kaltakoski rapids in the Petsame area, ceded to the Soviet Union in 1939. The Voima company has built a power station at Jaeniskoski for the Soviet Union and is now completing a second at Rajankoski in the same area.

INDIA

Wind Power

India expects to set up during the next five years nearly 30,000 windmills in wind-swept regions to help irrigation and generate electric power for rural small-scale industries. The project is estimated to cost Rs 70m. Examples of foreign made windmill generators are being obtained, meanwhile a suitable low-cost type using indigenous materials is being evolved by the Wind Power Committee of the Council of Scientific and Industrial Research. It is also proposed to establish a research station to study wind power, probably in Saurashtra or in Coimbatore district of Madras State, where high-velocity winds are common.

Railway Contract

An order valued at about £800,000 for converting plant, d.c. switchgear, and control gear for the first stage in the main line electrification of the Eastern Railway of India, has been obtained by the British Thomson-Houston Export Co. through A.E.I. (India). The order covers plant for six substations and three track section cabins on the main line from Calcutta (Howrah) to Burduran—a distance of 66 miles—and one track cabin at Karmarkundu, on the branch line to Tarakeswar. Low tension switchgear and certain substation auxiliaries are included in the order.

MALAYA

Infiltration again?

Electrical equipment manufacturers of Yugoslavia are making stronger efforts to

obtain a bigger share of the south-east Asian market for such goods, it seems. As the first step, a factory is being established in Burma to manufacture various electrical goods at what are considered comparatively low prices. To publicise the development, a motor vessel converted into a floating trade exhibition, has been calling at various ports around the Malaya coast. Among the goods exhibited on board are electric lamps, wires and cables, fans, generators, radio sets and batteries, torches, telephones and switchboards.

AUSTRALIA

Strike Delays Commissioning

Brisbane City Council is seriously perturbed at the "senseless industrial dispute" at its new Tennyson power station, which has delayed commissioning of further plant and caused the Council substantial financial loss. The strike, which began on 25 Feb., is by metal trades employees of the boiler construction contractors, Babcock and Wilcox Pty., Ltd. The strike, in support of higher margins, quickly spread to the firm's employees at the Southern Electricity Authority's Gibson Island power house. Chairman of the City Council Transport and Electricity Committee, Alderman Kringer, has said that if the strike does not end soon Brisbane can expect blackouts again next winter.

Victoria Scheme

The vast Wimmera area is to be linked up to the State Electricity Commission of Victoria's supply network, provided sufficient area loans are forthcoming to supplement the Government's loan funds. It is proposed to make a start this financial year with the erection of a transmission line 116 miles from Ballarat to Horsham, at a cost of about £400,000. The scheme concerns an area of 10,800 square miles from Stawell to the South Australian border, in which eventually 45,000 persons, 4,000 farms, and a small number of industries will be supplied with power. Cost of the whole scheme is put at £1½ millions. Linking of the Wimmera will complete the Commission's current programme for supply to the major regions of the State.

Repairs Needed

The Cairns Regional Electricity Board, Queensland, has been authorised to restrict for another month if necessary supply to consumers in its area of supply. This is to ensure demand upon the available generating plant can be kept within the capacity of the power station. The Minister for Mines, Mr McCathie, said this action had been necessary because of a breakdown of diesel generating plant at Cairns. Repairs were being carried out, the Minister said, and it was hoped they would be completed before serious restriction became necessary.

Supplies to Farms

Of the 73,000 farms in New South Wales, 40,000 were now being supplied with electricity, the Minister for Works and Local Government, Mr J. B. Renshaw, stated a few days ago. Since 1946, about £10m had been spent on the erection of 16,000 miles of rural lines to connect 24,000 farms and serve 42,000 consumers. The Government was already paying £1¼m subsidy and was committed to pay a total of £3¾m. At the present rate of progress every farm within economical reach of power lines could have electricity by 1960. The Electricity Commission's generating capacity to meet consumer demand had increased in five years from 500,000 kW to 1,000,000 kW.

NEW ZEALAND

Station Site?

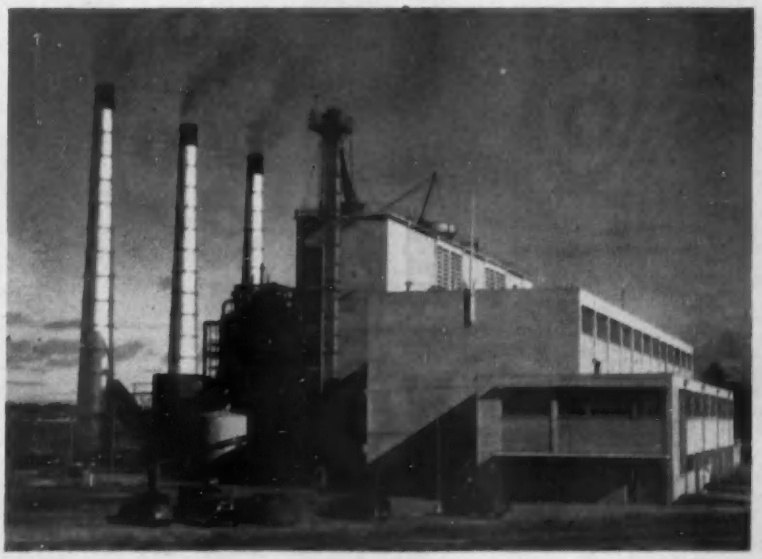
Test borings are almost complete on the likely site of the new 180 MW steam power station which is to be established in the North Island by the N.Z. State Hydro-Electric Department. This is on the bank of the Waikato River, 2¼ miles south of Mercer. Borings are understood to have established that the soil foundations are adequate. The site is regarded as being the best available, provided the present proposals to use the major quantities of coal from the Maramarua opencast coalfield are adhered to. That coalfield is only a few miles away across country. The consultants' proposal was to transport the coal to the power station by overhead cable way. The main trunk railway line, by which other could be brought from Huntly, runs within about half a mile of the site.

Urgent Funds

The N.Z. State Advances Corporation is to make an immediate payment of £250,000 to the Auckland Electric-Power Board, followed by subsequent payments up to a total of £450,000. The Board originally applied for £600,000. The funds are needed to meet the quarterly account of the State Hydro-Electric Department, and to pay for various goods on order, including £22,000 worth of switchgear already delivered.

Future Plans Sought

The Waitemata Electric Power Board maintains that the New Zealand Government is not looking far enough ahead in power-development planning. The Auckland Electric Power Board have also asked the North Island Technical Power Committee to draw up a long-term power plan. Meanwhile, a spokesman for the State Hydro-Electric Department has indicated that all available experts are concentrating their efforts on the additional short-range power plan approved in Apr. Apparently the whole planning staff is occupied with the present programme. This includes hydro-electric development and the building of the coal-fired station on the Waikato field, design and location of the oil-fired turbine plant, and the continuing development of geothermal steam at Wairakei and Kawerau. Long-term planning has only been temporarily halted because of shortage of trained staff.



Typical of the three "packaged" power stations obtained from the U.S.A. by the State Electricity Commission of Victoria, Australia, is this 30 MW station at Geelong, which has been in operation for some months now. The contract placed by the Commission included the supply of boilers, generators, and all auxilliary equipment, the supply and erection of the buildings, and putting the station into service. All plant required was supplied as complete pre-engineered units designed to facilitate rapid erection with the minimum of preparatory work on the site. The station, which has three 10 MW generators in line, is of unusual design for Australia in that the conventional boiler house has been dispensed with, thereby reducing building costs. The three 110 klb/hr boilers, which operate at 625 lbs/sq in., are completely out-of-doors except for the boiler operating face. The boilers are automatically controlled, fuel delivered by belt conveyor to the bunkers, is fed to the furnaces by mechanical spreader stokers. The station operates exclusively on brown coal purchased from the Wensley Brae open cut at Winchelsea, about 30 miles from Geelong. The plant consumes about 5,200 tons of fuel a week

Personalities

IN THE INDUSTRY

Mr E. Bruce Ball, C.B.E., M.A.(CANTAB.), M.I.MECH.E., formerly managing director, Glenfield and Kennedy Ltd., has been appointed an additional director of Metal Industries Ltd.

To commemorate the completion of 50 years' service each, **Mr W. E. Martin,** Paper Cable Department; **Mr C. V. Knight,** Transformer Department; and **Mr W. Cole,** of the Rubber Cable Warehouse, were presented with solid silver cigarette boxes, suitably engraved with the record of their association with Johnson and Phillips Ltd. The presentation was made jointly by **Mr G. L. Watev,** J.P., COMP.I.E.E., chairman and joint managing director, and **Mr W. Glass,** M.I.MECH.E., joint managing director.

Mr F. L. A. Morris, first assistant to the district consumers' engineer, at Penrith, North Western Electricity Board, has been appointed to a similar post with the Eastern Electricity Board at Stowmarket.

Retiring from the position of managing director of Edwin Danks and Co. (Oldbury) Ltd., **Mr. J. Smith,** M.I.MECH.E., has been appointed deputy chairman of the Company. **Mr L. W. H. Rea,** whose appointment as general manager of Edwin Danks has been previously announced, has been appointed to the managing directorship. Mr Smith first joined Edwin Danks as an apprentice in 1909, receiving training in the works and drawing office. In 1913 he joined John Russell and Co. (Walsall) as assistant to the chief engineer and, in 1915, he joined A. Harper Sons and Bean as a machine-tool designer for guns and heavy shells. From 1916 to 1919 he was chief engineer of the Government Cartridge Factory at Blackheath and, in 1919, he became assistant chief engineer to Kynochs Ltd. of Witton. He returned to Edwin Danks in Dec., 1920, as technical sales representative later becoming manager of the Erection and Repair Departments. He was appointed chief engineer in 1938 and managing director in 1943. In addition to his membership of the Institution of Mechanical Engineers, Mr. Smith is also a member of the Institutions of Heating and Ventilating Engineers, Fuel, and Welding. He is a member of the Advisory Committee on boiler-makers' work to the City and Guilds Institute, and a member of the Board of Governors of Oldbury College of Further Education.

Nominated as manager of the Essex sub-area of the Eastern Electricity Board is **Mr R. W. J. Benyon,** M.I.E.E., A.I.I.A., who has been manager of the Board's South West Essex district since 1953. Mr Benyon succeeds **Mr R. H. M. Barkham,** B.SC.(ENG.), M.I.E.E., who was recently appointed as the Board's chief commercial officer. Born at Princes Risborough, Bucks, in 1911, Mr. Benyon was educated at Aylesbury Grammar School, and received his early technical training in the Electricity Department of the Aylesbury Corporation. From 1933 to 1948 he held various technical and commercial posts in the Electricity Supply Industry at Barking, Colwyn Bay, Basingstoke, Beckenham and St. Helens. When the industry was nationalised in Apr., 1948, Mr Benyon became local manager of the St. Helens and Warrington districts of the Merseyside and North Wales Electricity Board. In Sept., 1949, he was appointed manager of the Eastern Electricity Board's Romford district and in 1953, when the Romford and Brentwood districts were merged, he became manager of the South West Essex District, which appointment he has held up to the present time.

Mr J. Clement, B.SC., M.I.E.E., who recently relinquished the managership of the Birmingham office of the British Thomson-Houston Co., Ltd., has now been appointed assistant manager, Home Sales at head office, Rugby. After graduating at Glasgow University in 1926 Mr Clement completed his engineering apprenticeship with B.T.H. Rugby in 1928. This was followed by experience on outside construction in the London area, leading to an appointment at head office in the Industrial Machines Department. He was then posted to Newcastle-on-Tyne in Aug. 1929, where he was largely engaged in dealing with the d.c./a.c. and 40/50 cycle changeovers; he was appointed manager in 1936. While in Newcastle Mr Clement was a member of the North East Coast Institute of Engineers and Ship Builders and was for some time on the local centre I.E.E. Committee and served as Chairman of the E.I.B.A. Local Advisory Committee. During the war years he was called upon to organise the D.I.E.E. on the North East Coast for the Machine Tool Control Section of the Ministry of Supply. In Dec. 1946 he was transferred to Birmingham office as manager, a position he held until June 1955, when he returned to head office preparatory to his new appointment. Mr Clement has been interested in the E.I.B.A. in the Birmingham area and is a vice-president of the Local Section. He has also served on various I.E.E. Committees.

Mr J. C. Raisbeck, Mr George Paul and **Mr I. W. Roberts** have been elected to the Board of Vactric Ltd. **Air Commodore G. W. P. Grant** has resigned from the Board.

A number of new appointments, effective as from 1 Aug. are announced by Johnson and Phillips Ltd. **Mr H. J. Olley,** has been made Cable Works Manager responsible for both the Rubber Cable and Paper Cable Works. Mr Olley joined the Cable Department of J. and P. in 1918 and later was made manager of the Cable Cost Department. In 1940 he also undertook control of the newly-formed Employment and Welfare Department. For many years he has been a member of

Mr J. Smith

Mr R. W. J. Benyon

Mr J. Clement

Mr H. J. Olley

Mr B. C. Brown

Mr W. Mann

Mr F. J. C. Holliman

Mr E. A. Twine

Mr C. E. Collar

Mr H. West

the Joint Industrial Council for the Cable Making Industry and has contributed in no small way to the good labour relations that exist in the industry. In his new post Mr Olley will be assisted by **Mr B. C. Brown** and **Mr W. Mann,** both of whom have held senior posts in the Cable Department. Mr Brown becomes assistant manager of the Paper Cable Works. **Mr F. J. C. Holliman,** who was previously assistant to Mr Olley in the Employment and Welfare Department has been appointed manager of this department, and **Mr E. A. Twine** has been promoted to manager of the Cable Cost Department. In addition to the above appointments, J. and P. announce that **Mr C. E. Collar,** A.M.I.E.E., has been made assistant manager of the Transformer Department, and **Mr H. West,** assistant manager of the Cable Estimating Department.

Mr W. J. Mackay, A.M.I.E.E., an official of the Dunfermline headquarters of the South of Scotland Electricity Board, has been appointed to the new post of administrative officer for the Board's Fife Area. Before his new appointment, Mr Mackay had been operations engineer. **Mr A. F. Morris,** who was previously with the North of Scotland Hydro-Electric Board, has been appointed meters' test and protection engineer.

Chairman of Cable and Wireless Ltd. since Apr. 1951, **Major-General Sir Leslie Nicholls,** K.C.M.G., C.B., C.B.E., M.I.E.E., has indicated his intention to retire from that position as from the end of Jan. next, in order to devote his time to outside interests. He became a director in Jan. 1947, was appointed managing director in 1950, and chairman the following year. Educated at Cheltenham College and University College, London, he served with the R.F.C. in the 1914-18 war, as signals officer with the Shanghai Defence Force in 1927, and in the Waziristan campaign in 1937-38. During World War 2 he served as chief signal officer to Field Marshals Alexander, Montgomery, Maitland Wilson and to General Eisenhower. He became chief signal officer, Middle East, in Jan. 1943. Six months later he was appointed chief signals officer to General Eisenhower at Allied Forces Headquarters. After the invasion of Europe, he rejoined General Eisenhower as deputy chief signal officer at S.H.A.E.F., and remained with him until its dissolution. He was awarded the O.B.E., the C.B.E., and became a Companion of the Order of the Bath in 1945. He is also a Commander of the American Legion of Merit and an Officer of the French Legion of Honour and Croix de Guerre with palm.

At a farewell gathering on 27 July, **Mr M. J. Mortimer,** M.I.E.E., Worthing district manager of the South Eastern Electricity Board, was presented with a set of golf clubs by Mr K. I. Davis on behalf of the district employees to mark his retirement after 50 years' service. Mrs Mortimer was presented with a bouquet. On the following day Mr H. Pryce-Jones, J.P., M.ENG., M.I.C.E., M.I.E.E., M.INST.F., Mid-Sussex Manager, presented a golf bag to Mr Mortimer on behalf of the district managers and senior officers of the Mid-Sussex sub-area.

Additional appointments to the board of W. T. Henley's Telegraph Works Co., Ltd., are announced. **Mr E. J. Vidler,** who has been general manager since 1 Jan., 1954, now becomes director and general manager, and **Mr S. J. Beaney,** secretary of the company since 1 Apr., 1954, becomes director and secretary. Mr Vidler joined Henley's as a junior in the Foreign Section of the Sales Department and progressed to the successive appointments of personal assistant to sales manager, assistant sales manager, and sales manager. In 1950 he became assistant general manager, and in Jan., 1954, he was appointed general manager. Mr Vidler is also a director of Southern United Telephone Cables Ltd., and of United Telephone Cables Ltd., and is Henley's accredited representative at all the conferences of the Cable Makers Association. Mr S. J. Beaney also began his business career in Henley's sales organisation which he joined in 1925. In 1950 he transferred to secretarial duties being appointed personal assistant to the secretary. Three years later he became assistant secretary, and secretary of the company on 1 Apr., 1954. Mr Beaney is also secretary of Henley's (South Africa) Telegraph Works Co., Ltd., and a director of Commercial Secretaries Ltd.

Formerly reader of Electronic Engineering in the Liverpool University, **Dr J. D. Craggs,** M.SC., PH.D., F.I.P., has been appointed to the Robert Rankin Chair of Electronic Engineering at that University, and **Dr F. D. S. Butement,** principal scientific officer at Harwell since 1951, has been appointed to the newly established post of senior lecturer in radiochemistry in the University's Department of Inorganic and Physical Chemistry.

Mr D. E. Lambert, B.SC.(ENG.), M.I.E.E., Mem. A.I.E.E., has been appointed manager of the switchgear division of Brush Electrical Engineering Co., Ltd., Loughborough, as from Oct. 1. For the past 30 years, Mr Lambert has been with A. Reyrolle and Co., Ltd. He has held several senior appointments, including assistant technical manager of the company, and is at present engineer-in-charge of technical co-ordination and manager of the British Short Circuit Testing Station, Ltd. Mr Lambert is well known nationally and internationally in connection with switchgear standardisation.

Formerly district engineer at Reading, **Mr E. R. Morgan** has been appointed district manager at Newbury, Berks, to the Southern Electricity Board, in succession to **Mr H. F. Brewer.** The latter succeeded **Mr F. T. Bushroyd** as district manager at Melksham. The new district engineer at Reading is **Mr T. Beck,** who held a similar post at Melksham, which is now to be filled by **Mr W. R. Kirkpatrick.**

Mr E. Lawrenson, M.A., has been appointed chief engineer of the Wireless Telephone Co., Ltd., Sheffield (a member of the Plessey group of companies). Earlier he was a senior engineer in the advanced development laboratory of Standard Telephones and Cables Ltd.

Industrial relations officer for the Cable Makers' Association for the past thirteen years, **Mr W. H. M. Jackson,** O.B.E., has retired; he is succeeded by **Mr T. H. Pike.** During that time Mr Jackson was also secretary for the Employers' Associations on the Joint Industrial Council for the Electrical Cable Making Industry.

OBITUARY

Mr E. Scott-Purdie, who joined the Stage Lighting Department of the Strand Electric and Engineering Co., Ltd., in 1945, died on 10 July, aged 45. Earlier he was with the General Electric Co.

Col A. M. Gibb, who died after a polo accident last week-end, was a son of Sir Alexander Gibb, the consulting engineer. Aged 54, he joined his father's concern as an engineer after leaving Cambridge.

Equipment for Industry

Drying by Infra-red Oven

DESIGNED for heat processing small articles and materials in batch production, the new standard infra-red oven manufactured by METROPOLITAN-VICKERS ELECTRICAL CO., LTD., Manchester, is suitable for paint stoving, lacquer drying and softening plastics, etc. Basically, the oven consists of a floor-mounted steel casing with infra-red heating elements fitted in the top of the case. Heating the materials within the oven is achieved by direct heat radiation from anodised aluminium reflectors mounted above the infra-red elements; stray radiation losses are minimised by covering floor and sides of the oven with anodised aluminium sheet. Lining the interior of the oven in this manner not only ensures maximum heat reflection, but also protection against atmospheric corrosion. Normally ventilated round the sides of the top cover, the oven can accommodate ducting for removing noxious fumes emitted by drying materials. Counter-weighting the drop-down door enables it to remain in an open or closed position and the door can also serve as a useful tray when loading the oven. Housed in the base of the oven, the control equipment consists of a switch fuse unit, energy regulator, contactor and "supply-on" indicator light. Total power consumption is 4 kW and the approximate overall dimensions are 5 ft high, 2¼ ft deep and 2¼ ft wide.

Metrovick offer this oven which employs infra-red heating elements

Small Motor Starter

A NEW version of a standard push-button, direct-on starter for motors up to 7½ h.p. on 340-550 V and 3 h.p. on 200-250 V supplies has been introduced by ELECTRICAL APPARATUS CO., LTD., St. Albans. This starter, known as the MF2 Autoswitch, incorporates E.A.C.'s latest overload and single-phasing prevention unit employing bi-metal elements which are indirectly heated by replaceable heaters. Continuing E.A.C.'s standard practice, the Autoswitch's single-phase protection unit functions independently of the overload setting. Fitted with a no-volt release, the triple-pole contactor is magnetically operated and has no flexible connections or hinge pins to any of the moving parts. Replacement of the non-weld type contacts has been simplified by enabling this maintenance to be effected without removing the unit from its case. An aluminium alloy die-casting provides a sturdy case for the starter and leaves ample space for wiring the new, simplified terminal arrangement.

The new version of E.A.C.'s starter for motors up to 7·5 h.p. on 340/550 V supplies

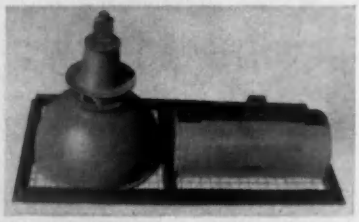
Portable Unit aids H.V. Field Tests

MUCH of the apparatus for testing high voltage electrical equipment in the field does not lend itself to mobility due to its heavy construction. But, by providing a unit which is undeniably portable, having a weight of less than 25 lb and capable of delivering 15,000 V d.c. at a low current, LINTRONIC LTD., 149 Strand, W.C.2, have done much to ease the lot of the field test engineer. Providing a high voltage supply from a hand operated transformer-generator, the equipment also has provision for utilising a.c. mains in situations where this facility is available. The addition of inductive and capacitive circuits minimises any fluctuation of the rectified, smoothed d.c. output, which is likely to be caused by varying generator speeds. Controlling the output by means of a rotary, positive stop, selector switch eliminates accidental overshoot common to continuous variable switches.

Designed for h.v. field tests is this portable power supply unit by Lintronic

"Mazda" Cradle Fitting

DEVELOPED originally for use in the Velindre Mill of the Steel Co. of Wales, the BRITISH THOMSON-HOUSTON CO., LTD., Crown Hse, Aldwych, W.C.2, offer an industrial blended colour lighting fitting which features particularly simplified maintenance. Shown at the recent B.E.P.C. exhibition, it comprises, essentially a steel tray carrying a floor of rigid wire mesh and divided into two parts to carry a 1·5 kW tungsten filament lamp reflector and horizontal mercury fitting housing a 1 kW MA/H lamp. Each fitting rests on wire guards which also serve to prevent broken glass from falling. Since the cradle can be cantilevered out from cat-walks, and are connected to their control gear by flexible cable, they are readily accessible for cleaning or repair.



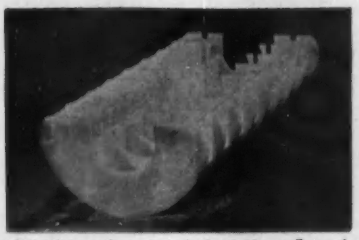
"Mazda" blended light cradle fitting for cantilever mounting on cat-walks or high bays

Mercury Lamp Range Extended

COLOUR corrected, medium-pressure mercury lamps of the MBF/U category for industrial or public lighting, supplied by PHILIPS ELECTRICAL LTD., Century Hse, Shaftesbury Ave, W.C.2, now include a 250 W lamp to facilitate the choice of lamp for such purposes. It operates from the choke normally used for 250 W MA/V lamps and is physically interchangeable with them. In light output, a lantern housing the new lamp is said to be roughly equivalent to that of a standard tubular, fluorescent lantern containing three 5 ft, 80 W, lamps.

Atlas' New Louvre Attachment

NEW translucent opal plastic louvre attachments for 1½ in. fluorescent tubes have been introduced by the Atlas lighting division of THORN ELECTRICAL INDUSTRIES LTD., 105 Judd St, London, W.C.1.



"Atlas" translucent opal plastic louvre attachments for 1½in. dia. fluorescent lamps

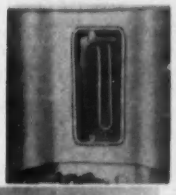
Under the name "Clipluve" these attachments are designed for single-tube fittings. They may be attached to bare tubes in any fitting to eliminate glare yet give a good degree of diffusion without materially affecting efficiency. "Clipluve" is moulded in sections 11 in. long and is packed in cartons containing sets of five to fit a single 5 ft 80 W tube. The fitment is easily installed. Sections are merely pressed into place against the tube.

Heated version of Hoover Washer

IN response to a demand for washing machines with self-contained heating, HOOVER LTD., Perivale, Greenford, Middlesex, introduced to Scotland last month a version of their Mark II washing machine fitted with a 2 kW heating element. To incorporate the heater without altering the size of either machine or tube, the heater has been set in a small compartment in the bottom of the tub and is normally covered by a grill. No thermostat control is incorporated and it is stated that the water may be brought to boil if desired. Should the heater, which is controlled from a knob at the side of the machine, be accidentally switched on whilst the tub is empty, a thermal cut-out disconnects it from the supply. The new washer sells for £43. plus £13. 17s. 6d. p.t.

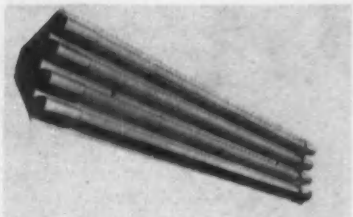
Although the machine has initially been introduced in Scotland only, we understand that it is soon to be available in the Channel Isles, and in the north of England, from where its sales will be extended southwards. In other respects the Mark II differs little from its non-heated relation; having the "Hoover" pulsator set in the side of the tub, and automatic pump for emptying water.

Right, the heater fitted in the Hoover Mark II washer (normally it is covered by a grill) and and below, the control knob is seen in the side of the machine



"Windolux" Fittings for All

MADE originally for a large group of stores, the 5 ft 4 lamp "Windolux" fitting has now been made available to all dealers by SCEMCO LTD., 6 Soho St, W.1, and is included in their catalogue at a price of £21.



Scemco's "Windolux" four lamp fitting for use in stores lighting

The Scemco "Windolux" range includes single, twin, triple and four lamp units in 3 ft, 4 ft and 5 ft lengths and 2 ft single and twin 20 W units and 2 ft twin and four lamp 40 W units. Prices range from £4. 10s. 6d. up to the 5 ft 4 lamp fitting at £21.

Fraikad Fittings

WROUGHT iron and wooden lighting fittings in attractive designs are now available from FRAIKAD LTD., 59 Brompton Rd, London, S.W.3.

Both ranges are available in table models and single, two, three and four light pendant and wall fittings. The wrought iron fittings are available in cream or malt black in prices ranging from 33s. 6d. plus 5s. 6d. p. tax to 157s. 6d. plus 25s. 8d. p. tax, prices exclusive of shades. The wooden styles in oak or cream/sepia cost from 35s. plus 5s. 9d. p. tax to 189s. plus 30s. 9d. p. tax, exclusive of shades. Gilt fittings cost 5% extra.

Permaheat's New Bed Warmer

EXTENDING their range of electrically heated blankets and pads, PERMAHEAT LTD., Spectator St, Manchester 4, announce the introduction of their "Popular" model designed for general use. It is a single heat model, 50 in. by 24 in., of 60 W rating and available, ex-stock, at 220/240 V, a.c. or d.c., using a waterproof element. Available in a choice of four colours, the new blanket has a list price of 66s. plus 11s. p.t.

For the Electrical Trade

TRADE PUBLICATIONS

REINFORCED PLASTICS.—Fibreglass Ltd., Ravenhead, St. Helen's, Lancs, have issued a new booklet in the Fibreglass series on reinforced plastics. This is an instructional booklet as well as catalogue of the firm's products.

DOMESTIC IRONERS.—H511-6023 Ed. A. is a new leaflet issued by the Hotpoint Electric Appliance Co., Ltd., Fletton, Peterborough, covering their rotary and table ironers.

WINDING MACHINERY.—Recent issue by The Midland Dynamo Co., Ltd., Leicester, is a leaflet describing their "Quickway" armature winding machine.

METAL SECTION.—New "Metsec" building catalogue is available from Metal Sections Ltd., Oldbury, Birmingham.

METAL FINISHING.—Spray Gun Bonderizing the paint bonding process by The Pyrene Co., Ltd., Metal finishing division, Great West Rd, Brentford, Middx., is detailed in leaflet MFD3/355/08.

ALLOYS.—Henry Wiggin and Co., Ltd., Wiggin St, Birmingham 16, have issued a new publication describing the application of the powder metallurgy process to the production of wrought nickel and nickel alloys.

SWITCHGEAR.—New issue by A. Reyrolle and Co., Ltd., Hebburn, Co. Durham, is pamphlet No. 1281 on Type JK55 ring main switches and the tee-off fuse-switch units for service at up to 11 kV.

GEARED MOTORS.—New catalogue section issued by Electropower Gears Ltd., describes the Types E.S.R. and E.S.R.V. 50 fractional geared motors with co-axial shafts.

COLLOIDS.—Four page leaflet "A List of 'Dag' dispersions of colloidal graphite and other solids" has been issued by Acheson Colloids Ltd., 18 Pall Mall, S.W.1.

ACCESSORIES.—Useful illustrated Broadsheet showing the range of products available from Nettle Accessories Ltd., Harper Rd, Wythenshawe, Manchester, has been produced in answer to many requests from industry.

NEWS OF THE WEEK

C.E.A's. New Financial Policy

More Money to be Secured Through Tariffs

AN explanation of how the electricity supply industry would contribute towards the stabilisation of the country's economic position was given during the debate in the Commons last week following the Chancellor's statement on the current situation on the Monday. The explanation was particularly significant in that it disclosed a change in the Central Electricity Authority's financial policy. Mr Butler stated that the C.E.A. was to make provision in raising revenue for financing part of their capital expenditure without resort to borrowing. This throws further light on the Authority's earlier statement that surpluses accrued from charges had to be maintained and even increased if financial stability was to be assured, "and more money provided to help finance the continuing expansion of the industry." The Chancellor also referred to the C.E.A.'s intention of investing money in themselves by applying to internal needs certain superannuation moneys which would otherwise be invested outside the industry. As regards economies in major projects, the electricity industry were to defer certain schemes mainly concerned with distribution.

Earlier in his speech, Mr Butler referred to bank advances, and said the reason why they were considerable was that when asked originally to start the credit squeeze, the banks were financing, in particular, the gas and electricity undertakings and that had clouded the whole of their operation. Now those industries were going on the market for their money and were not so dependent on bank advances, it was hoped to get a direct result from the credit squeeze. Mr Butler also said that the latest restrictions would not affect any programme already announced, unless a nationalised industry could with reason and without doing any harm, slow it up. Nuclear, and other, power station projects, and the railway modernisation plan, will not be effected therefore.

Four New Branches

BRANCH offices have been opened in Glasgow, Manchester, Newcastle-on-Tyne and Nottingham by the Birkenhead firm of Cantic Switches Ltd. A fifth office under the management of Mr N. Rayner is being planned in Leeds. Addresses of those already established are 248 West George St, Glasgow, 'phone Central 3739 (manager: T. C. Paton); 32 Deansgate, Manchester, 'phone Blackfriars 3851 (manager: J. T. Jolley); Sun Insurance Bldgs (Room 31), Collingwood St, Newcastle, 'phone 29171 (manager: W. K. Freeman); and 37 Talbot St, Nottingham (manager: A. E. Royle).

MINES ENGINEERING

RULES prescribing qualifications to be held by electrical and mechanical engineering staff at coal mines are set out in the new "Mining Qualifications (Mechanics and Electricians) Rules, 1955." These rules, which have effect from 1 Aug. last, apply under the Coal Mines (Mechanics and Electricians) General Regulations, 1954. Certificates are required by electrical engineers and electricians (two grades) at mines. The rules now published lay down practical training requirements, syllabuses from examinations, and exempting qualifications. For electrical engineers, the standard is five years experience and the equivalent of H.N.C. or a degree. Experience for five years is also required for the Class I electrician's certificate, together with O.N.C. or some equivalent qualification.

Order from New Zealand

A SECOND order for switches has just been received by Line Equipment Ltd., from the State Hydro Electric Dept., at Wellington, New Zealand. It involves 25 600 amp 220 kV triple pole, vertical break, outdoor isolating switches, and was forwarded by the company's Wellington agents, Samuel Brown Ltd. This order follows one already in hand for 220 kV and 110 kV switches for the same Dept.

TWO MORE AREA BOARDS RAISE THEIR TARIFFS

INCREASED charges for electricity were announced last week by the E. Midlands and S.E. Electricity Boards. As in the case of the N.W. and Yorkshire Boards' new tariffs, reported in our 28 July issue, the new rates will become effective on 1 Oct. In the E. Midlands area, domestic consumers at present paying a quarterly charge of 4½d. a unit for the first block of units and 1d. a unit in excess, will pay 5d. a unit in the first block, and 1d afterwards. The number of units in the block will go up from 30 to 36 for the first three rooms and from 9 to 11 for each additional room. Tariffs for farms and combined premises and commercial tariff 4 will be increased similarly. Commercial tariffs 2 and 3 (flat rates for separately metered supplies) will be raised to 5½d. a unit for lighting and 1·6d. for other purposes. Unit charges under the industrial block tariff will be 2·1d. for first 3,000 units per quarter, 1·85d. for next 3,000 units and 1·6d. for remainder.

Increases to domestic and commercial consumers in the S.E. area are mainly twofold. Quarterly and fixed charges remain unaltered, as also are the off-peak rates. Unit charges in domestic and business two-part tariffs will go up from 1d. to 1·1d. Seeboard thus becomes the first of the Boards to raise their domestic unit charge on a two-part tariff above the 1d. At the same time the S.E. Board has taken the opportunity of standardising flat and block prices for cooking, heating and power. At present these range from 2d. to 4d., but in future all will be 2½d. per unit.

University Training Queried

CONSIDERABLE divergence of opinion within the engineering industry concerning university-trained engineers is reported by the Government's Advisory Council on Scientific Policy in their annual report for 1954-55. The Council had noted in an earlier report the existence of a view that increase in the size of university population might have an undesirable effect on the number and quality of boys entering industry as apprentices. An enquiry conducted amongst leading firms in the engineering industry, which covered both this question and that of the value to industry of certain forms of post-graduate work in engineering at the universities, has been made by the Council, and they proposed producing their report later in the year analysing the replies received.

Much of the report is concerned with the present difficulties about supply of science teachers in schools, and the Council expresses some concern about the proportion of scientists staying on at universities after taking their first degree.

Parks Commission to meet C.E.A.

AT the first conference of national park authorities in London at the end of last month there was plenty of support for the oft-repeated view that the cost of laying electricity transmission cables underground should be met from national funds. It was stated at the conference that the National Parks Commission was arranging a conference with the C.E.A. to discuss the matter.

Trade Prospects in Egypt, Ethiopia and the Sudan

THE report of the U.K. Trade Mission, led by Mr G. C. R. Eley, to Egypt, the Sudan and Ethiopia, was published last week. The party of ten, which included Mr J. F. Perry, managing director of Metropolitan-Vickers Electrical Export Co., Ltd., visited those countries last February. Of the three countries toured, Egypt, of course, offers the best opportunities for U.K. exporters.

Development programmes in Egypt provide for considerable expansion of power facilities. Because, in recent years U.K. firms have found difficulty in working to Egyptian contract terms, they have played little part in power schemes now being carried out. The Egyptian Government has agreed to try and find a solution if another representative was sent out and the Mission adds the hope that B.E.A.M.A. will follow the matter up. New schemes being planned should provide fresh opportunities for the supply of generating plant, and switch and transmission gear. Main scheme (still under discussion) is the High Aswan Dam project, and a final report on its technical aspects was expected this summer. It will be recalled that an Electricity Commission was established last year to plan a comprehensive network capable of meeting estimated requirements for the next 25 years. It is noted, however, that Electricité de France were invited to act as technical consultants. Demand for electricity is expected to rise from the present 1,163 million kWh to 5,570 million kWh in 1965 and up to 13,600 million kWh by 1975. At the present time, no tender documents had been issued for new thermal stations in the Alexandria-Kafr el Danwar area and Suez Canal area. On the transmission side, present plans provide for a 500-mile 380 kV double-circuit line from the High Dam power station; three substations at Nag Hammadi, Minya and Cairo; and about 620 miles of 150/132 kV single circuit and 745 miles of 15 kV line.

On the industrial side, local firms are producing lamps and accumulators, copper wire and cable, and in a limited way, washing machines and refrigerator cabinets. As power becomes more freely available and cheaper, there should be a growing demand for domestic appliances.

Comment on the possibilities of sending electrical plant and equipment to the Sudan states that the extent of the recent expansion programme, now almost complete, suggested that there was little scope for some years. We note that provision has been made at Burri power station, Khartoum, for the installation of three 10,000 kW sets in the future, and that the Sudan Railways are designing a second power station at Wadi Halfa. The Government is also keenly interested in hydro-electric development, although there are numerous difficulties involved.

Prospects in Ethiopia would appear at first glance to be slightly better. Future development is likely to be divided between the major Coca Dam scheme and a number of smaller extensions. Consideration is being given to a transmission line from the new Coca station to Addis Ababa, Diredawa and Harer, but the main policy appears to be to expand local stations where hydro-electric power is available. Overall a number of comparatively small sets of generating equipment will be needed in the next 10 years to keep pace with increasing demand.

New Crawley Showrooms

NEGOTIATIONS have just been completed between the S.E. Electricity Board and Crawley Development Corporation for the acquisition of a site at 50-52 Broadway, in the centre of the New Town, for use as a service centre. Crawley district showrooms of the Board have hitherto been in the High St, and in fact, the staff have worked in four different buildings and in cramped conditions. The new showrooms will occupy a prominent corner site, and include suitable display and demonstration facilities.

Bolton Sub-Area Staff Have New Office Block

NEW Bolton sub-area headquarters were officially opened by Sir Joseph Hallsworth, chairman of the N.W. Electricity Board, recently. Mr. E. G. Wardle, sub-area manager presided at the ceremony, attended by the Mayor of Bolton, Alderman S. Entwistle. These offices have been occupied for some time now, and were originally an old Co-operative Society building, purchased to effect economies in sub-area administration.

Electricity Board on Ice

DUNFERMLINE Ice Rink, officially opened in 1939, has been acquired by the S. of Scotland Electricity Board, we hear. The Board is expected to take over on 1 Oct. The old rink will be used as the Board's main stores in Fife, and for garage, workshop and office accommodation. It will facilitate the centralisation of storage, engineering and transport departments. No purchase price has been stated, but the original cost of the ice rink was £40,000. It was offered for sale last April.

OFFICIAL PUBLICATIONS

REPORT OF TRADE MISSION TO EGYPT, ETHIOPIA AND THE SUDAN. (See this page.) H.M.S.O. 6s.

CLEAN AIR BILL. (See page 162.) H.M.S.O. 1s.

SCIENTIFIC POLICY. 8th Report of Advisory Council on Scientific Policy 1954-55 (see page 182). H.M.S.O. 6d.

LOAD SPREADING. Report of Elect. Sub-committee of Joint Consultative Committee (see page 184). H.M.S.O. 4d.

MINING QUALIFICATIONS (MECHANICS AND ELECTRICIANS) RULES, 1955. (See page 182). H.M.S.O. 1s.

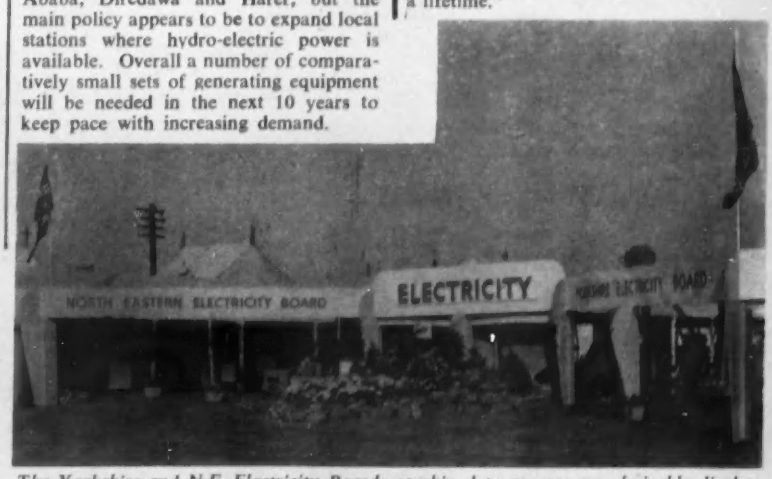
INDUSTRIAL AND DOMESTIC COAL CONSUMERS' COUNCILS. Annual reports for 1954-55. H.M.S.O.

APPRENTICE SCHOLARSHIP

THE Apprenticeship and Training Council for the electrical contracting industry have awarded a scholarship for 1955 to 20-years-old Derek Howe, a student at Oldham Municipal College. He is at present employed as an apprentice by the Co-operative Wholesale Society in Manchester. The scholarship is worth about £750 and is tenable for a 3-years degree course at a University or a Higher National Diploma course at a technical college. Grants in respect of outstanding merit have also been made to Edward Ingle, and Michael Hamman, both apprentices with Marryat and Place Ltd., and students at East Barnet Grammar School and Kingsbury Grammar School.

Safety Week in October

A NATIONAL Industrial Safety Week is being organised by the Industrial Safety Division of the Royal Society for the Prevention of Accidents as this year's effort to reduce the number of accidents in British factories. It will take place between 24 and 29 Oct. Object of the campaign will be to encourage all factory workers to "Start a safety habit today" and to remember that "safety habits last a lifetime."



The Yorkshire and N.E. Electricity Boards combined to present an admirable display of all kinds of electrical equipment and appliances at the Great Yorkshire Agricultural Show last month. Every section of farming was catered for, with displays for dairy and horticultural farmers. In a central covered space, hammer mills and food mixing machines were demonstrated, and a half-scale barn hay drying floor was constructed. On the domestic stand cookery demonstrations were given at frequent intervals

COMPREHENSIVE SCHOOLS

THE position of the comprehensive school in the educational system of the country was the subject chosen by Mr J. Brown, Education Officer of the L.C.C., when he spoke at last week's luncheon of the Batti-Wallahs. He outlined the progress which had been made in extending educational facilities to the population over the past century. The range of ability of children was wide and not all were suitable for a grammar school education. The aim of the comprehensive school was to provide the most suitable education for all categories of children. Mr Brown commented on the present overcrowding and on the shortage of teachers. Dr Dunsheath proposed the Vote of Thanks, and Mr Forbes Jackson was in the Chair. Next luncheon will be on Thursday, 29 Sept.

More Golf Finalists

THOSE from the Eastern area who will compete in the Electrical Industry's Golf Championships on 26 Sept. were decided last month at the Letchworth Golf Club, Herts. Nineteen players competed and the eventual winner was Mr C. O. Pilbeam with Mr J. R. C. Williams as runner-up. Best scratch score was returned by Mr A. Love.

Load Spreading Arrangements for Next Winter

PROSPECTS as regards electricity supplies throughout next winter are slightly better than they were last year, states the report of the Electricity Sub-Committee of the Joint Consultative Committee, published last week. Disconnection of supply will be unnecessary unless there is extremely severe weather, but voltage and frequency reductions may be required on some occasions. Main recommendation, (all of which have been accepted by the Government) is that Regional Boards for Industry should continue to make load spreading arrangements. A change is suggested in the winter peak hours to 4 p.m. to 5.30 p.m. in November, 8 a.m. to noon, and 4 p.m. to 5.30 p.m. in Dec. and Jan., and 8 a.m. to noon in February. Domestic and commercial consumers are again to be asked to economise at peak hours, and Regional Boards are asked to encourage the use of private generating plant to help out.

It was also stated that no further annual reports are to be issued unless unforeseen developments occur.

R.A.F. ENGINEERS

CADETS of the No. 1 entry at the Henlow Technical College were on parade at a passing out ceremony at the College recently. They were the first set of cadets to complete the three-year training course at the College which was described in the ELECTRICAL TIMES of 26 May. Reviewing Officer on this occasion was Air Chief Marshal Sir John Baker, Controller of Aircraft, Ministry of Supply. Eleven cadets on parade were being commissioned into the electrical section of the R.A.F. Technical Branch. They were told by A.C.M. Sir John Baker that they were pioneering a new and enlarged responsibility for the technical branch of the R.A.F. Other cadets were proceeding to a three-year university course after one year at the College under another section of the R.A.F. technical scheme.

The First Half-Century

On the invitation of Manchester Electricity Committee a number of builders in the city had a conference with the Committee last week on the subject of the supply of current for the electric lighting of house property in residential neighbourhoods generally. Now that the price of the current is about to be reduced to 4½d. per unit the committee thinks there should be an increased demand for putting the necessary fittings into new property. The builders' deputation agreed that the electric light was very satisfactory in houses, and that the present difference between the price of electricity and that of gas would, when the reduction takes effect, be more than made up. The first difficulty to be met was the cost of wiring, added to the fact that in so many houses gas must also be put in for cooking. Practical suggestions were made which may lead to an increased use of electricity in Manchester residential districts.—*From our issue of 3 Aug., 1905.*

Luxurious Lighting for New Luxury Yacht

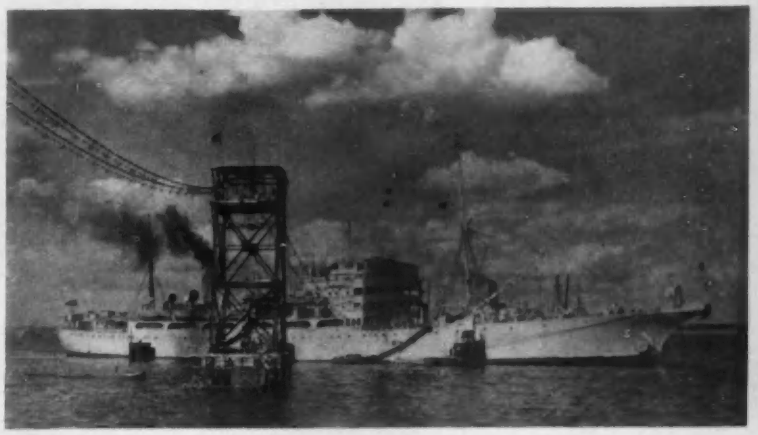
THE luxury yacht *Lahloo II*, built by Vosper Ltd., of Portsmouth, includes the special d.c. fluorescent lighting system with MCFD/U lamps devised by Philips Electrical Ltd. This circuit ignores two of the items usually associated with the operation of fluorescent lamps on a d.c. supply, a choke for starting and a polarity reversal switch. In addition, the wire-wound ohmic resistor is replaced by a barreter-type ballast. Design of the circuit for operation of fluorescent lamps of 2 ft or less, makes it particularly suitable for ships as well as aircraft. The system operates on voltages from 80 to 130 with a nominal voltage of 110.

In the *Lahloo's* installation fluorescent and tungsten lamps have been blended to achieve maximum efficiency and decorative effect. In the stateroom fluorescent lamps have been mounted in recessed panels and incandescent lamps in wall fittings. The strip light above the mirror contains a vacuum tubular lamp. The saloon depends upon fluorescent lamps for its general lighting whilst fluorescent lighting is supplemented by tungsten lighting in the deck lounge. Ceiling-mounted totally-enclosed fittings are employed in the galley, and in the engine room too, good diffused illumination has been obtained on all working surfaces. The fittings used were designed by Best and Lloyd Ltd.

Philip's lighting in the deck lounge (left) and the owner's stateroom (right) in the new luxury yacht Lahloo II

Trans-Atlantic Cable Loaded at Erith

Post Office Cable Ship Monarch *was due to sail from the Thames estuary last weekend with some* 1,300 *miles of cable aboard, destined for the first deep sea section of the trans-Atlantic telephone link. The cable link will eventually connect Britain, Canada and the U.S. Our illustration shows the cable being loaded aboard the* Monarch *direct from the Erith works of Submarine Cables Ltd. A special tower was constructed in the river to support the cable at mid-span*



NEWS IN BRIEF

Fifty apprentices employed by the Plessey Co., Ltd., have been on a ten-day tour of the Continent. The holiday was arranged by Mr D. A. Chappell, the company's education and training officer.

Electrical installations in all Bridlington's prefabs are to be inspected.

Fifty employees of Clarke Chapman and Co. have postponed their annual holiday to move machinery and equipment to a new workshop built by the company.

It is reported from Istanbul that Westinghouse and Schneider have signed a contract with the Turkish Government for the construction of a factory to make capital electrical equipment.

Hoover Ltd. are to supply two washing machines for the forthcoming Commonwealth Trans-Antarctic Expedition for use at the British and N.Z. section bases.

British Driver-Harris Co. Ltd., have held a technical conference at their Cheadle works. Representatives from associated companies in France, Italy, Austria and Spain attended.

The £1m extension to Rugby Radio, the G.P.O.'s main long-range transmitting station, was officially opened by the Postmaster General last week. Twenty-eight high power transmitters are being installed, and the entire order was placed with Marconi's Wireless Telegraph Co. Ltd.

Service!

Sir,—I would like to convey through your columns my thanks to the local Electricity Board. My electric shaver operates on a.c. only, and unfortunately the hotel at which I have been staying is supplied with d.c. On inquiring at the Electricity Showrooms, the manager immediately suggested I might call in each day to shave there. His private office has been placed at my disposal during my pleasant holiday at Bexhill.

Thanks to the warm welcome, I have never felt I was intruding. Such service from a nationalised industry proves that the personal touch is still to be found—at least in Bexhill.

GRAHAM J. LOVE,
Grove Park, S.E.12.

(Extracted from "Bexhill Observer.")

QUESTIONS IN PARLIAMENT

Dual Firing

THE C.E.A. fully recognised the need to save coal by the installation of coal and oil firing equipment in new stations, Mr G. Lloyd assured Mr Gower last week. They were already planning two large new generating stations for dual firing.

Coal Imports and C.E.A.

ABOUT 5 million tons of imported foreign coal was expected to be consumed by the C.E.A. in 1955, Mr G. Lloyd stated. He told Mr G. Nabarro that the N.C.B. would make all purchases abroad and spread the extra cost over all consumers.

Capital Investment

AS a result of the new economic measures, Mr G. Nabarro asked for the supply industry's revised capital investment programme from now until 1958, and the expected diminution in new installed generating capacity. Mr G. Lloyd said consultations were going on but as the authorised programme for 1955-56 and 1956-57 was no more than adequate to meet estimated demand, and was already in progress, he could not anticipate any capital savings in that field.

Siting Nuclear Power Stations

IN a written reply Mr G. Lloyd explained that since the main function of nuclear power stations was to meet national base load requirements, proximity to local sources of demand was only one factor in determining sites. Maj. Hicks Beach had suggested that new nuclear power stations should be situated close to the source of demand.

Tax on Water Heaters

REMOVAL of purchase tax from electrical and gas water heaters was suggested by Mr Coldrick in view of the new hygiene regulations for shopkeepers. Mr H. Brooke said the matter would be considered but it could not be regarded as a conclusive reason for exemption from tax.

Area Board Sales

NO new directions are being given to Electricity Boards concerning promotional sales and advertising in view of the new economic measures. Mr G. Lloyd said he was confident the Boards would conduct their publicity taking full account of the situation.

Private Generation

THE Minister of Fuel and Power was asked by Mr G. Nabarro last week for an estimate of the aggregate capacity of private and independent generating plant. He said the capacity was about 4½ million kW. There was no information available on the extent to which that was working in parallel with the grid.

Oil Tests

THE Minister of Supply was asked by Mr Burden how far the same tests and principles are applied to lubricating oils from all sources when approval was being considered for his Advisory Panel on heavy duty engine oils. Mr R. Maudling replied that the same tests are applied by the Advisory Panel to all oils tested irrespective of the source of supply, and he gave an undertaking that if there were any new sources of supply this procedure would be followed in exactly the same way.

Capital Expenditure

IN a written answer, Mr G. Lloyd stated that, generally, the capital expenditure of the Coal, Electricity and Gas Boards had approximated to the approved level in each year since nationalisation. He had been asked by Mr C. I. Orr-Ewing how much of the approved capital expenditure was in fact spent by the N.C.B., the C.E.A. and the Gas Boards in each year since nationalisation. Mr. Lloyd added that in 1950 and 1951 the N.C.B., and in 1949 and 1953 the Gas Boards were

between 15% and 25% below. In some years original approvals had been extended to allow for programme acceleration.

Ionising Radiations

IN view of the increased use of nuclear power in industry, Mr S. Hastings asked if a memorandum could be published setting out the main known dangers and means of avoiding them. He was told that in 1953, a handbook on "Precautions in the Use of Ionising Radiations in Industry," was issued by the Factories Dept. of the Ministry of Labour.

Infra-Red Lamp Installations

ALLEGATIONS that an increasing number of fires were being caused by the unsatisfactory installation by unskilled persons of infra-red lamps on pig and poultry farms, were made by Sir A. Bossom. He advised the issue of a pamphlet to farmers advising them and warning them against bad installation. Mr D. Heathcoat Amory said such dangers had been referred to in a pamphlet already issued and a leaflet being prepared on the prevention of fires on farms, would also include suitable references.

Fires on Farms

LATER in the week Sir A. Bossom asked if the Minister of Agriculture would institute a campaign to reduce the number of fires on isolated farms. He suggested advertising the desirability of regular inspection of old wiring installations which electricity boards undertook at a reasonable fee. The Minister said the matter had already been stressed in his Dept.'s leaflet "Fire Prevention on Farms." Another appeal for care in preventing fires in the countryside was about to be made, he said.

London Tube

NO decision as to the actual construction of the contemplated tube railway between Victoria and Walthamstow had been taken yet, Mr J. Boyd-Carpenter stated in a written answer. Mr E. Fletcher had asked when the line would be completed.

Sayings OF THE WEEK

"It is a disgrace that in an age which enjoys Government expenditure of hundreds of millions a year on "scientific research," there should be purchase-tax of even a penny-piece on electric washing machines." . . . E. SNOWDEN, writing to the *Yorkshire Observer*.

"If we cannot have electricity we can only stop farming; we are finished." . . . ALDERMAN J. H. ROWE, at a public inquiry at Stratford upon Avon, concerning the erection of overhead lines.

"Millions of pounds were being spent by local authorities on providing new houses on estates which were further and further removed from the centres of electricity supply." . . . MR D. BELLAMY, chairman, Yorkshire Electricity Board, speaking at a conference of local authorities.

ELECTRIC SUPPLY NEWS

Douglas (I.O.M.)

Units sold in the Douglas area by the Corporation undertaking during the year ended 31 Mar. last totalled 19·762 millions, compared with 19·195 millions in the previous year. Output of the steam power station was 24·568 million units, of which 1·576 millions were exported to the Isle of Man Electricity Board's system under the latest reciprocal arrangement. That Board also supplied 790,302 units to the Corporation. Consumption per consumer in the Douglas area averaged 2,066 units for the year, compared with 2,045 units for the previous period, while the average revenue figures were 2·635d. and 2·443d. per unit respectively. Mr C. Anderson, the borough electrical engineer and manager, also reports an increase of 382 in the number of domestic appliances on hire, and it is evident that strong efforts are being made to increase the use of electric cookers and water heaters in the aim to raise consumption still further. After deducting capital charges, the year's operations resulted in a net credit balance of £4,619, which can be considered satisfactory.

Durham

The North Eastern Electricity Board is to spend £145,000 improving the electricity supply in the Horden Colliery area, where the Board has taken over responsibility for supplies from the National Coal Board.

Perthshire

Yet another switching-on ceremony by the North of Scotland Hydro-Electric Board took place recently—at Glen Lyon, in Perthshire. The Glen Lyon distribution scheme, the fourth to be completed in the neighbourhood of the Board's Breadalbane hydro-electric project, involved the erection of 22 miles of 11 kV line, at a cost of £34,500, to provide electricity to a dozen farms and about 60 houses. At the ceremony, Sir George McGlashan, County Convener of Perthshire, said since the Board took over responsibility for supply in the county in 1948, some 13,900 consumers had been connected, excluding Perth city—an increase of 175%. It was estimated that there were about 10,000 potential consumers in Perthshire still to be connected, many of them in remote country areas. But it was hoped that in ten years over 90% of the possible consumers would be linked up.

South Wales

The South Wales Electricity Board connected 1,311 farms to its system last year, bringing the total to 6,768, Mr W. A. Gallon, deputy chairman of the Board, stated at the Royal Welsh Show. Of the latter total, half had been connected since vesting day. In April, May and June this year, 301 farms had been connected (against 209 in the same period last year), and it was hoped to supply nearly 2,000 in the year ending 31 Mar., 1956. There were 25,000 farms in South Wales, 3,500 of which were so inaccessible that it was unlikely that they would ever be supplied with electricity, he said. Of the remaining 21,500 farms, about 14,000 had still to be connected, and if the Board could proceed at this year's rate, they might be able to complete farm electrification in less than eleven years. The Board spent about £5 millions a year on capital expenditure and about £1¼ millions on rural development extension. Although the average consumption of farms increased to 3,608 units for the year ended 31 Mar. last, they had a long way to go before they were using electricity at the same rate as other consumers.

Stratford-upon-Avon

The application of the Midlands Electricity Board for consent to erect overhead lines in and around Stratford, was strongly supported by Alderman J. H. Rowe, owner of a local farm, at the recent public inquiry. The application concerned supplies to Bridgetown, Bishopton, Baraset and Rayford Camp. For the Board, Mr G. P. Wilson, legal adviser, said that approval of the planning authority (Warwickshire C.C.) had been received to the proposed lines, both inside and outside the borough. Cost of the o.h. lines proposed within the borough would be £1,518, but if underground cables were used the cost would rise to £6,290. Mr. J. P. Heins emphasised that the Board was faced with the need to reinforce and extend its network. For the Council, Mr T. E. Lowth, town clerk, referred to the amenity factor—the Council had a genuine desire to prevent the encroachment of o.h. lines in territory under its jurisdiction, but recently they had permitted certain stretches of o.h. cables to be erected after most careful consideration. They did not wish to deprive anyone of the benefits to be gained from an electricity service, but they felt that the continued erection of o.h. cable was detrimental to the appearance of a town such as Stratford.

LIGHTING SCHEMES

Appleby. T.C. has approved a scheme for electric lighting in the main streets, to cost £4,346.

Brierley Hill. The U.D.C. propose to install improved lighting on the main roads.

Larne. Fluorescent street lighting is to be erected for the R.D.C. in Greenisland, at a cost of £4,125.

Redcar. T.C. recommended to carry out next year another stage in the street lighting conversion scheme, estimated to cost £20,000.

Scunthorpe. T.C. is making application for loan sanctions involving £14,536 for street lighting improvement schemes.

COMPANY ACTIVITIES

REMARKABLE advance in the profits of Gas Purification and Chemicals under its new management has been one of the features of the week. With less than a year's use of the Grundig group, profits jumped from a few thousands to over £281,000 and are now running at the rate of £450,000 per annum, while the net assets now total £350,000. These figures include nothing from its latest acquisition, Modern Machine Tools. The profits referred to cover a period of 15 months to March last. It has all been done on a capital of £73,000, plus a note issue of £40,000. The dividend of 137½%, compared with 10% can be taken on an annual payment in view of the short period of working of some of the new subsidiaries. On that basis the 2s. shares at 45s. 3d. yield just over 6½%.

Looking ahead, the profits of the firm appear to be over 400% on the equity with a prospective earning yield of nearly 20%. Prospects are such that even at the present price of 45s. 6d. the shares do not appear to be dear. The proposed raising of the authorised capital from £100,000 to £500,000 is a factor which probably has bonus possibilities.

There are many ways of receiving television. Mr J. S. Wills chairman of Broadcast Relay Service told of new developments at the annual meeting.

In many blocks of London flats where the company's system is operated it is converting communal aerial television systems to provide the reception of the second television programme. Preparations are also being made to convert aerial television receivers out on hire to receive the additional programme.

As regards new subscription television systems, Mr Wills made it clear that the wired television systems developed by the company have been designed so as to enable subscribers to receive additional programmes through a coin box or otherwise. There is already a serious shortage of radio channels and the importance of this development should not be underestimated.

Despite a 50% jump in profits, Mr J. E. Sherlock, chairman of British Thermostat Company was quite cautious about future prospects. He is worried about the "constant recurrence of strikes which upset the rhythm of production and also the need to counteract the recent wages agreements and the consequential increased cost of material and component stocks." Yet another problem is the shortage of labour at the Sunbury factory brought about by the influx of industry where the demand for manpower already exceeds supply and where few suitable houses are being built. But Mr Sherlock is not sitting down under these difficulties.—*From our City Correspondent.*

Brown Brothers Ltd.

The directors propose to make a free scrip issue on a one-for-one basis, for which Treasury consent has been obtained. The present issued Ordinary capital consists of £1,307,520 in £1 shares. The Board emphasises that the proposed adjustment to the company's capital structure does not imply the intention to distribute the same percentage dividend.

Drake and Gorham Ltd.

The electrical contracting subsidiary is meeting severe competition in this country, and in spite of the large volume of enquiries, orders can only be obtained at very low prices; thus only the most careful attention to detail makes it possible to ensure a profit on any contract, Mr R. H. M. Drake, the chairman, reports. He believes that really severe competition slows progress in technical development. Mr Drake adds that there is a considerable volume of work in hand, and order books are healthy. A subsidiary company has been formed in Nigeria where there is a rapidly developing market for large contracting work.

Year to 31 Mar.	£ Trading Profit	£ Net Profit	% on Ord. Earned	% on Ord. Paid	Ord. Price High	Ord. Price Low
1952	97,041	19,026	25	5	—	—
1953	53,469	8,487	8	5	12/–	10/–
1954	108,258	34,167	36	7½	18/–	17/6
1955	93,586	34,481	35	7½	18/4	18/4

Dubilier Condenser Co. (1925) Ltd.

Quantitative production last year exceeded that of the previous period, although during the early months some departments were not operating to full capacity. Mr F. H. McCrea, the chairman, reports there was also an increase in exports. During the current year additional productive capacity is being brought into commission. The outlook is promising, for the value of outstanding orders is greater than a year ago and the sales turnover for the first three months shows a satisfactory increase.

Year to 31 Mar.	£ Trading Profit	£ Net Profit	% on Ord. Earned	% on Ord. Paid	Ord. Price High	Ord. Price Low
1951	214,750	69,790	100	20	3/3	2/1
1952	411,212	130,832	194	28*	3/1	1/6
1953	419,639	114,588	115	25	4/4	2/10
1954	351,958	112,765	113	25†	5/1	3/3
1955	263,378	115,096	87	25	5/9	3/10

*Plus 40% capital bonus.
†Plus 25% capital bonus.

General Electric Co. Ltd.

Amplifying the results for the year to 31 Mar. last, given in the preliminary statement (noted last week), Sir Harry Railing, the chairman, stated that the increased turnover was achieved both in capital and consumer goods, with only a slight increase in the stock and work in progress. The total exports for the period did not quite reach the previous year's record, and expansion in overseas markets is becoming increasingly difficult in view of keen competition, import restrictions and local manufacture. The group's overseas companies showed a slight increase in profits on the previous year, however. The order book at the end of Mar. last, both for consumer and capital goods, was satisfactory, but the directors point out that the position with regard to certain consumer goods at home has since become less favourable owing to Government measures to curb internal spending. Group assets at 31 Mar. amounted to £80,924,967 (*£70,473,579*), while liabilities totalled £21,290,682 (*£19,456,071*).

Year to 31 Mar.	£ Trading Profit	£ Net Profit	% on Ord. Earned	% on Ord. Paid	Ord. Price High	Ord. Price Low
1951	7,424,716	1,978,039	81	22½	99/6	81/3
1952	8,617,275	2,091,114	69	22½*	46/1	35/9
1953	6,519,615	1,266,054	17	11½	46/–	36/3
1954	8,264,047	2,364,345	34	12½	60/6	37/6
1955	9,889,324	3,452,546	45	14	71/6	51/3

*Plus 100% capital bonus.

Permali Ltd.

Rapid developments in the company's affairs continue to evolve, and at some stage it is likely that the directors will recommend some further increase in the fixed capital, Col. C. F. Hitchins, the chairman, stated at the annual meeting last Thursday.

Phoenix Telephone and Electric Works Ltd.

After taxation, etc., group net profit for the year to 28 Feb. last is £54,482 (*£54,483*), and the dividend is again 15%.

Richardsons, Westgarth and Co.

The Board are considering the question of how far it may be necessary to procure additional finance for the capital expenditure programme in hand and contemplated, Mr O. J. Philipson, the chairman, stated last week.

James Scott and Co. (Electrical Engineers), Ltd.

Dealings are expected to start next Tuesday in the shares, part of the capital of this prominent Scottish concern, for which marketing arrangements on the London and Glasgow Stock Exchanges were completed recently. The issued capital consists of 200,000 6½% £1 Cumulative Preference shares and 1,016,148 5s. Ordinary shares. Bentworth Securities subscribed for the Preference, placing them at par, together with approximately 250,000 of the 5s. Ordinary purchased from the present shareholders. The Ordinary shares were placed at 11s. 3d.

Simon-Carves Ltd.

The likely marketing of shares in this concern, possibly in the autumn, is still being considered by the Board, Mr. R. B. Potter, the chairman, stated at last week's annual meeting. No final decision has yet been made but if arrangements are brought to a satisfactory conclusion, a public offer for sale of Ordinary capital in units of 5s. may be expected.

Dividends Declared

Brown Brothers. Interim 2½% (*same*).
Hoover Ltd. Interim 10% (*same*).

COMMERCIAL INFORMATION

Contracts Open at Home . . .

Dates given are the final for receipt of tenders unless otherwise stated.

6 Aug.—Lytham St. Annes T.C. Concrete columns with lanterns for Group B mercury discharge lighting in St. David's Rd, North.—See 28 July issue.

6 Aug.—Malvern U.D.C. Steel columns with fluorescent and sodium lighting units to Group A between Malvern and Malvern Link.—See 28 July issue.

6 Aug.—Peterborough T.C. Installation in 72 dwellings on Walton estate.—Advertised in 28 July issue.

6 Aug.—Stafford T.C. Classes A and B concrete columns and lighting equipment. —Advertised in 21 July issue.

8 Aug.—Co. Down. Installation in 34 dwellings at Castlewellan.—See 28 July issue.

8 Aug.—St. Albans T.C. Concrete group B lighting columns.—See 21 July issue.

8 Aug.—Stockport T.C. Rewiring at Churchgate Hse.—See 28 July issue.

10 Aug.—Southend-on-Sea T.C. Stanton 8F columns and 85 W sodium lanterns, etc.—See 28 July issue.

11 Aug.—Belfast T.C. Passenger/goods lift of 2,000 lb capacity at Power Station West.—Advertised in 30 June issue.

11 Aug.—Bootle T.C. Supply of concrete columns for street lighting. Borough Surveyor, Town Hall.

11 Aug.—N. Ireland. Installation at Massereene Hospital, Antrim.—See 28 July issue.

11 Aug.—Liverpool T.C. Installation at Sefton General Hospital.—See 28 July issue.

12 Aug.—Liverpool T.C. Domestic electrical goods for Children's Home.—See 28 July issue.

13 Aug.—Bodmin T.C. Sodium lighting units with concrete columns, wall brackets and outreach arms along London-Penzance Rd.—See 28 July issue.

13 Aug.—Chepstow U.D.C. Steel columns and 17 wall-mounting brackets, with sodium lanterns and auxiliary equipment on A48.—Advertised in 21 July issue.

13 Aug.—Halifax T.C. Two electrically driven pumps.—See 14 July issue.

15 Aug.—Carlisle T.C. Installation at Harraby secondary modern school.—See 28 July issue.

15 Aug.—Rochdale T.C. Installation at Technical School in Nelson St.—See 28 July issue.

17 Aug.—Scunthorpe T.C. Supply of concrete columns, 140 W sodium and 80 W mercury discharge lanterns, etc., and erection and wiring of 14 25 ft and 142 15 ft columns in street lighting improvements. C. Cooper, Borough Surveyor, Comforts Ave. Deposit £2. 2s.—Advertised in this issue.

19 Aug.—East Ham B.C. Street lighting equipment for Little Ilford Lane, Church Rd, Browning Rd and Gladstone Ave, involving concrete columns with lamps, lanterns and ancillary gear.—See 21 July issue.

19 Aug.—N. Ireland. Various electrical accessories, in year from 1 Oct.—See 28 July issue.

19 Aug.—Litherland U.D.C. Supply of electrical apparatus, cable, brackets, lanterns, etc., for conversion of 523 gas street lights to electricity. Engineer and Surveyor, Town Hall.—Advertised in this issue.

19 Aug.—Midlothian. Supply and erection 263 80 W mercury fluorescent lamps on 15 ft steel columns at Newtongrange-Easthouses-Gowkshill. Also 20 85 W sodium lamps on 25 ft concrete columns at Newtongrange. Separate contracts. County Surveyor, 32 Palmerston Place, Edinburgh.

19 Aug.—Surbiton T.C. Street lighting comprising sodium vapour discharge lamps on concrete columns along Kingston By-Pass.—See 28 July issue.

20 Aug.—Arnold U.D.C. Supply only of concrete columns for street lighting in Breck Hill Rd. Engineer and Surveyor, Arnot Hill Hse, Arnold, Notts.

20 Aug.—Penge U.D.C. Group A and B concrete columns, with lanterns, etc.—See 28 July issue.

24 Aug.—Carlow (Eire) U.D.C. Duplicate electrically driven pumping plant near Sion Cross.—See 28 July issue.

25 Aug.—Dublin. Electrical installation at Iveagh Hse, St. Stephen's Green. J. Tyrrell, secretary, Office of Public Works, Dublin. Deposit £1.

26 Aug.—Belfast T.C. Supply of (a) automatic fire fighting installation of water-jet emulsion-forming type; and (b) medium voltage substation distribution board, not metalclad. Electricity Dept., East Bridge St.—Advertised in this issue.

27 Aug.—Preston R.D.C. Class A and B street lighting schemes involving 66 points on Liverpool Rd, 113 points on Leyland Rd, and 72 points along three lanes, and conversion scheme along side roads involving 232 points. All in parish of Penwortham. Council Offices, Guildhall St, Preston. Deposit £2. 2s.—Advertised in this issue.

27 Aug.—Reigate T.C. Supply and erection of street lighting equipment on Reigate-Hookwood Rd and London-Castlefield Rd. Borough Surveyor, Town Hall. —Advertised in this issue.

27 Aug.—Wrexham R.D.C. Lighting and power installations in 97 houses and bungalows on sites at Broughton, Cefn, Esclusham Below, Gwersyllt and Penycea. T. A. Bowen, Engineer and Surveyor, Imperial Bldgs, Regent St. Deposit £2. 2s.

29 Aug.—Preston. Street lighting equipment for Class A scheme in Blackpool Rd, Lea, and Class B scheme.—Advertised in 28 July issue.

30 Aug.—Basingstoke (Hants). Supply of electric lamps to Park Prewett Hospital in year from 1 Oct. F. Hales, Group Secretary, Park Prewett Hospital Committee 47, Basingstoke.

31 Aug.—Seaham U.D.C. Electrician's materials required for maintenance of 3,600 houses for one year. Housing Manager, Estates Dept., Deneside.

1 Sept.—Batley (Yorks). Electrical rewiring at Batley General Hospital. G. W. Batchelor, secretary, Dewsbury, Batley and Mirfield Hospital Committee, 20 Oxford Rd, Dewsbury.

1 Sept.—New Windsor T.C. Electrical installation in reconstruction work at Alma Rd, Corporation Depot. Borough Engineer, Kipling Building, Alma Rd.

5 Sept.—Cheltenham T.C. Group A sodium discharge lighting comprising supply of 123 140 W non cut-off lanterns, etc., supply and erection of 113 steel columns with fitting and wiring of tenderer's equipment, and same as steel columns above, but for fitting and wiring of another firm's equipment, along Bath to Lincoln trunk road. G. Gould Marsland, Borough Engineer, P.O. Box 12, Municipal Offices. Deposit £3. 3s.—Advertised in this issue.

7 Sept.—Kingussie (Inverness) T.C. Steel columns, lanterns, lamps, etc., for sodium lighting along A.9.—See 28 July issue.

9 Sept.—Belfast T.C. Extensions to and modifications on existing Reyrolle switchboards at six substations; and five outdoor transformers.—Advertised in 21 July issue.

19 Sept.—Waterford (Eire). Installation at Central Technical Inst., Parnell St.—See 28 July issue.

1 Oct.—Islington B.C. Rewiring of the Council's Public Baths, Greenman St. —Advertised 14 July issue.

Your Queries Answered

Readers are invited to make use of our free enquiry department which possesses wide resources including an index of trade information with over 100,000 entries

A Selection from the 102 queries answered this week

Tube Laminations and Eng. Co., Ltd., makers of louvre fittings—address for? T.B.—Desborough Park Rd, High Wycombe, Bucks.

"Magic" washing machines, agents for? C.A.C.—Metalcraft Mnfg. Co. (Canada) Ltd., 39 Berners St, W.1.

"Turmix" mixers, suppliers of? L.O.—A. E. Warner (London) Ltd., 56 Brewer St, W.1.

Domestic cooker control unit fitted with timeswitch and electric clock, makers of? B.C.—Metalform Ltd., 258 Grays Inn Rd, W.C.1.

"Lammix" food mixer, address for? D.C. —H.M.V. Sales and Service, Blythe Rd, Hayes, Middx.

"Roto-grill" infra red cooker with spit, suppliers of? D.E.—Allen Walters and Co., Ltd., 6a St. Johns Hill, S.W.11.

"Permaster" hairdryers, makers of? M.I.—Bestfriend Electrical Co., Ltd., Diceland Works, Banstead, Surrey.

Domestic fan-heaters, makers of? D.E.—Gillott Electro Appliances Ltd., Cotswold Works, Chalford, Glos.; H.M.V. Sales and Service, Blyth Rd, Hayes, Middx.; Carter Electrical Co., Ltd., Eastern Works, Eastern Ave, Romford.

No date stated—Calne T.C. Supply and erection of 36 15 ft concrete columns, 28 brackets and poles, 88 lanterns, etc., for replacement of gas street lighting by electricity. Borough Surveyor, "Patford Hse," Calne.

No date stated—N. of Scotland H.E. Board. Lighting and heating installation at Glascarnoch power station, Ross and Cromarty. Merz and McLellan, 72a George St, Edinburgh. Deposit £2. 2s.—Advertised in this issue.

No date stated.—N. of Scotland H.E. Board. Supply and erection of 33 kV switchgear and ancillary equipment for Dounreay substation. Kennedy and Donkin, 12 Caxton St, London, S.W.1. Deposit £2. 2s.—Advertised in this issue.

No date stated—Scarborough. Electrical work in renovation of Abbey wards at St. Hilda's Hospital, Whitby. L. Hartley, secretary, Scarborough Group Hospital Committee, Scarborough Hospital.

. . . and Overseas

*Details of items marked * may be obtained on application to the Board of Trade, Lacon House, Theobalds Rd, W.C.1, quoting reference.*

15 Aug.—Canada. Supply of one 12,500 kVA generator for British Columbia Power Commission's Whatshan hydro-electric development at Lower Arrow Lake. Documents from Commission, P.O. Box 500, Victoria, B.C. B.o.T. (Ref.: ESB 15757/55).*

19 Aug.—South Africa. Supply of twenty 550:110 V, 50 cycles, single-phase, 50 V-amperes, class A double wound, dry type potential transformers. Electricity Dept., City of Durban, Municipal Buildings, West St. Contract No. E.2618. B.o.T. (Ref.: ESB 15694/55).*

20 Aug.—Iraq. Supply erection, etc., of complete diesel-electric power plant at Samawa factory of United Cement Co., comprising either four units of 1,200 kW, or five units of 900 kW 0·8 p.f. 3,300 V 3-phase, 50 c/s a.c. United Cement Co., Kdhairy Building, King Faisel Sq, Baghdad. B.o.T. (Ref.: ESB 15603/55).*

23 Aug.—U.S.A. Supply of 230, 115 and 14·4 kV power circuit-breakers for Granite Falls substation, Transmission Div., S. Dakota, Missouri River Basin project. (Contract No. D.S.-4465.) Bureau of Reclamation, Building 53, Denver Federal Center, Denver 2, Colorado. B.o.T. (Ref.: ESB 15361/55).*

1 Sept.—Belgium. Supply of (*a*) 40 generator sets of 30 kW, (*b*) 15 sets of 150 kW, and (*c*) 38 compressors (total value £115,000). Apply to Ministere de la Defense Nationale de Belgique, Service Generale des Constructions Militaires, Direction Pipeline, Caserne Prince Baudouin, Place Dailby, Bruxelles.

7 Sept.—Portuguese East Africa. Tenders (No. 186/55) invited for supply of total of 24 items of telephone equipment by Ports, Railways and Transport Dept., Lourenco Marques. B.o.T. (Ref.: ESB 15503/55).*

13 Sept.—Australia. Director of Posts and Telegraphs, Melbourne, requires supply of power rectifiers of varying capacities. Documents (PMG Schedule No. C.7303) from Chief Procurement Officer, Commonwealth of Australia, Australia Hse, Strand, London, W.C.2.

16 Sept.—Australia. Tenders (E. 21/55) invited for supply of centralised load control equipment for substation 31, Toowong, and substation 42, Ashgrove. Documents at 10s. 6d. per copy from Chief Engineer and Manager, Dept. of Electricity, Brisbane City Council, Kelvin Hse, Adelaide St, Brisbane. B.o.T. (Ref.: ESB 15170/55).*

22 Sept.—Portuguese West Africa. Supply and installation of steam boiler with feeder and auxiliary equipment; one 500 C.V. steam turbine, condenser and auxiliary equipment; a 400 kVA alternator and 400 kVA transformer; and control box; all for extension to Malange power station. Direccao dos Servicos Tecnicos da Camara Municipal de Malange, Angola. Deposit Esc. 53,000.00. B.o.T. (Ref.: ESB 15337/55).*

26 Sept.—Australia. Tenders (contract No. 449) invited for supply of seven 330 kV, 54 MVA single-phase transformers for Yass substation. Electricity Commission of N.S.W., Sydney. B.o.T. (Ref.: ESB 15018/55).*

27 Sept.—Australia. Manufacture, supply, etc., of two 110/10 tons electric overhead travelling cranes and accessories, for T.1 power station, N.S.W. Contract 50,033. Documents at £1 a set from Stores and Supply, Goulburn St, Surry Hills, Sydney, N.S.W., or Snowy Mountains Hydro-Electric Authority's other offices in Melbourne, Canberra or Cooma.

30 Sept.—Australia. Supply of 33,000 V metalclad switchgear for stage 2 of Tennyson power station. Chief Engineer and manager, Dept. of Electricity, Brisbane City Council, Kelvin Hse, Adelaide St, Brisbane. Contract E.22/55. Documents at 10s. 6d. per copy. B.o.T. (Ref.: ESB 15169/55).*

30 Sept.—South Africa. Supply of eight electric storage battery operated fork lift trucks with carrying capacity of 6,000 lb. Tender No. F.5036. Stores Dept., S. African Railways, Johannesburg. B.o.T. (Ref. ESB 15003/55).*

PRICES of cable metals and other materials

Figures quoted are the official prices ruling on Tuesday, 2 August

	£ per ton	Weekly change £	Price last year £
COPPER, standard class A (settlement)	360	−12	234½
,, (3 months)	352	−11	233½
R.T.S. (Rhodesian Selection Trust) group price*	325	+45	—
LEAD, refined pig, min. 99·97% purity (cash)	108	+½	92½
,, (3 months)	107½	+½	91½
TIN, refined, min. 99·75% purity (settlement)	761	−9	745
,, (3 months)	754	−8	741
ALUMINIUM, ingots 99·99·5%	171	—	156
ZINC, virgin, min. 98% purity (cash)	90½	−½	73½
,, (3 months)	90½	−½	74½
RUBBER No. 1, RSS, spot (per lb.)	41d.	+1½d.	20½d.
,, c.i.f. basis, ports, Sept. (per lb.)	40½d.	+2½d.	20½d.
ARMOURING :			
Galv. Steel Wire (0·104 in.)	54	—	52
Mild Steel Tape (0·014 in.)	41½	—	40½

(*Fixed price c.i.f. U.K., operative till end of August and then subject to change at 24 hours' notice, to "consumers willing to instil a degree of stability into the resale price.")

Gazette Announcements

COMPANIES ACTS

L. Carlen and Co. Ltd. Resolution for voluntary winding-up passed at meeting on 20 July. E. S. Browne, C.A., 41 North John St, Liverpool, was appointed liquidator and creditors are asked to send particulars to him by 30 Aug.

Thomasson and Co. (Shrewsbury) Ltd. Liquidator is R. F. Bendall, F.C.A., 126 Colmore Row, Birmingham, and creditors are requested to send particulars to him by 31 Aug.

Domestic Refrigeration Services Ltd. Creditors are asked to send particulars to liquidator by 1 Sept. R. E. Beckett, of Lloyds Bank Chambers, Park St, Walsall, is liquidator.

BANKRUPTCY ACTS

First Meeting

Tunbridge Wells. John H. Pickwell, trading as J. H. Pickwell and Co., electrical retailer at 79 London Rd, East Grinstead. First meeting will be at Official Receiver's Office, 8 Old Steine, Brighton, on 5 Aug. at 11 a.m., and public examination at The Court Hse, Crescent Rd, Tunbridge Wells, on 28 Sept. at 11 a.m. Date of receiving order, 20 July.

Dividends

Tunbridge Wells. Jack C. R. Gillitt, electrical contractor trading as C. Gillitt and Son at 19 Stangrove Rd, Edenbridge. First and final dividends of 5½d. in £ payable at 52 Old Steine, Brighton, on 16 Aug.

Trade Notes

New Factory. James Scott and Co. (Electrical Engineers) Ltd., are building a new factory at Finnieston St, Glasgow, to undertake manufacturing and maintenance work.

Expansion. The new factory at Gosport of Ultra Electric Co. Ltd., is expected to be opened next April.

Change of Address. The Power Petroleum Co. Ltd., North Eastern Branch, Leeds, have moved to new offices at Bardon Chambers, Infirmary St, Leeds 1. Telephone No: Leeds 29366.

New offices and showroom for the Portsmouth district of Hoover Ltd., have been opened at 91/95 Commercial Rd, Portsmouth. (Telephone No.: 70972/3.) The workshop and storeroom for the district is located as hitherto at 67 Elm Grove, Portsmouth.

Contracts Placed

London C.C. Installations in two blocks of dwellings at Kensal Hse, Kensington, Buchanan and Curwen Ltd., £3,242; also installation of radio interference suppression equipment for 74 lifts on various housing estates, Bennie Lifts Ltd., £2,980.

Hebburn (Dur) U.D.C. Installation in 120 houses in Monkton Lane, John Calvert (Electrical) Ltd., £3,388.

BUSINESS PROSPECTS

Home

Adwick-le-Street U.D.C. Scheme submitted for erection of £100,000 swimming bath.

Ainwick U.D.C. Erection of 64 houses on Greensfield estate. G. Beaty, Surveyor to Council, The Council Hse, Wagonway Rd.

Co. Antrim. Erection of new welfare centre at Ballyclare. Architects are Thomas T. Houston and Co., 26 College Gardens, Belfast.

Bangor (N. Wales). Scheme approved by Hospital Management Committee for extensions to general hospital. Estimated cost £300,000.

Belfast T.C. Construction of new wing extension at St. Dominics high school in Falls Rd. W. H. McEvoy, chartered quantity surveyor, 73 May St.

Birkenhead T.C. Swimming bath proposed on Woodchurch estate is estimated to cost £185,000.

Birmingham T.C. Construction of 18 shops, 17 flats and offices at The Fordrough, West Heath. A. G. Sheppard Fidler, City Architect, Civic Centre.

Brierley Hill U.D.C. Permission sought to begin third phase of Civic Centre, including town hall. Cost estimated at £75,000.

Brighton T.C. Scheme for three-tiered seafront entertainment centre approved in principle. Cost estimated at £200,000.

Cambridge. Capital grant of over £141,000 authorised for extensions of headquarters and replacements at National Inst. of Agricultural Botany.

Campbeltown T.C. Burgh offices to be demolished and new offices built.

Cardiff. Factory to be built on Newport Rd estate for Standard Box and Carton Co., Ltd., Merthyr Tydfil.

Cheshire. About 30,000 acres of land at Macclesfield to be acquired for proposed college of further education and two secondary modern schools.

Coventry T.C. Revised scheme for civic theatre in Corporation St has been approved. Estimated cost of project is £205,420.

Croydon T.C. Erection of second instalment of technical college. R. Atkinson and Partners, architects, 13 Manchester Sq, London, W.1.

Cumberland. Tenders may soon be invited for erection of £193,000 secondary school at Cockermouth. It is also proposed to build secondary school at Egremont.

Dagenham T.C. Construction of 58 flats, etc., in Eagle Ave. Borough Engineer and Surveyor, Civic Centre.

Derby. Elliott Cox and Partners, 172 Buckingham Palace Rd, S.W.1, are architects for Platers and Stampers Ltd.'s new factory on industrial estate. Development not expected for some time.

Doncaster T.C. Plans approved for Intake secondary modern school estimated to cost £151,254.

Dover. Approval received for first stage of scheme to enlarge College of Physical Education at Homington. Estimated cost £90,000.

Dublin. Erection of National School at Blanchardstown. J. Tyrrell, secretary, Office of Public Works, Dublin.

Edinburgh. University of Edinburgh to extend medical buildings in George Sq, at cost of about £1m. Quantity surveyors are Reid and Gibson, 2 Melville St.

Also S.E. Scotland Hospital Board has included two new projects in next building programme. They are bacteriology laboratory at City Hospital, and biochemistry laboratory at Royal Infirmary. Resp. costs estimated at £110,000 and £30,000.

Finsbury. Block of offices to be built in Goswell Rd for City and West End Properties Ltd. Architects are Ronald Ward and Partners, 29 Chesham Place, Belgrave Sq, S.W.1.

Grimsby T.C. Western secondary girls' school in Little Coates Rd is estimated to cost £150,000.

Hambledon (Sur.) R.D.C. Erection of block of 16 bungalows at Cranleigh. Engineer and surveyor, Council Offices, Bury Fields, Guildford.

Harlow (Essex). C.C. have approved erection of new college of further education estimated to cost £245,938.

Havant (Hants). Plans in hand for factory and research laboratory in New Lane for International Chemical Co., Ltd. Cost will be about £300,000.

Ilford. Proposals for extensions costing £22,000 at St. Augustine's R.C. school, Barkingside, have been approved.

Leeds T.C. Plans approved in principle for central swimming baths in New York Rd. Scheme expected to cost about £400,000. Free Church of England Central Trust, London, planning to build church at Cross Gates.

Matlock (Derby). County Council seeking permission to borrow £230,000 for purchase and adaptation of Smedley's Hydro Hotel for use as council offices.

Millom (Cumb). Approval granted for erection of £184,000 comprehensive school. Work expected to start next spring.

Newark R.D.C. Erection of 20 houses in Coleman Ave, Balderton. Wm. Saunders and Partners, 24 Castle Gate.

North Riding. Building programme for next financial year will include New Scarborough High School for boys, Richmond county modern school for boys and girls (£200,000), Eston Central county modern school for boys and girls (£112,000), Thornaby county modern school for boys and girls (£112,000), and extensions to Malton and Guisborough grammar schools (£75,000).

Northants. It is proposed to erect secondary modern school at Deanshanger (£97,381). Revised plans in hand for Kettering Grange and Weston Farell primary schools (£96,400).

Oxford. Block of offices to be built on Parkland site for A. C. Nielson and Co., Ltd. Architects are Howard Crane and Partners, 7 Buckingham Gate, London, S.W.1.

Peterborough R.D.C. It is proposed to install electric water heating systems in 56 pre-war council houses at Ailesworth, Eye, Newborough and Peakirk.

Pocklington (Yorks). Plans approved for new county secondary school with houses which are estimated to cost £172,349.

Portsmouth. New buildings on Clarence Pier to cost about £250,000, proposed by Clarence Pier Co., Ltd.

Prestwich T.C. Plans approved for erection of £50,000 civic hall.

St. Ives T.C. It is proposed to erect 20 houses and 8 old people's bungalows.

Scunthorpe. British Oxygen Ltd. planning large extension on 12 acre site on corner of Winterton and Warren Rds.

Southwell (Notts) R.D.C. Erection of 20 dwellings at Lowdham. Architects, W. Sanders and Partners, 24 Castlegate, Newark-on-Trent.

Whitley Bay. Preliminary report prepared on proposed new town hall, swimming pool, winter gardens theatre and motor coach station.

Overseas

Cuba. Mr Homer W. Parker, Calle 24, No. 405, Vedado, Havana, wishes to contact U.K. manufacturers of steam driven turbines up to 400 h.p., water pumps from 4,000 g.p.m., and electric motors from ½ to 400 or 500 h.p., a.c., 50 and 60 cycles. Greatest demand for motors is in 5 to 100 h.p. range.

Kuwait. Contract with U.K. manufacturers of numerous electrical goods sought by the Almoosa Trading and Contracting Co., Ltd., P.O. Box 130, Kuwait. Goods include copper tubing, transformers, switchgear, switchboards, paper insulated cables, street lamp standards, junction boxes, lamps, floodlights, welding electrodes, etc., etc.

TRADE MARKS

This information is extracted from the Official Journal by permission of the Controller.

Vyon. 742,201. Class 1. Filtering materials, etc. Pritchett and Gold and E.P.S. Co. Ltd., Dagenham Dock, Essex.

Monarch. 738,302. Class 7. Sewing machines. Nepric Ltd., 73/79 Hurst St, Birmingham 5.

K in design. 741,371. Class 7. Automatic machines for dispensing beverages. W. M. Still and Sons Ltd., 29/31 Greville St, E.C.1.

Magna. 739,978. Class 9. Electrically ignited cigar and cigarette lighters. Magnatex Ltd., Harlington Works, Bath Rd, Harlington, Mddx.

Distrolite. 741,648. Class 11. Fluorescent fittings. F. Crumblehulm, Spring Lawn Cottage, Chorley New Rd, Bolton.

Pevic. 739,223. Class 16. Identification sleeves for marking cables and connections, etc. Wireless Telephone Co. Ltd., Hallamgate Works, Crookes Rd, Sheffield 10.

NEW COMPANIES

Extracted from the Register issued by Jordan and Sons, Ltd., 116 Chancery Lane, W.C.2.

Barr's Retail Ltd. Market Place, Denton, Manchester. Manufacturers and repairers of, and wholesale and retail dealers in electric lamps, fires, etc. Nom. cap.: £10,000. Dir.: Mrs. E. Barr.

Electric House (1955) Ltd. Market Place, Denton, Manchester. Manufacturers and repairers of and wholesale and retail dealers in electric lamps, fires, etc. Nom. cap.: £20,000. Dir.: P. L. Barr.

Cefni (Electrical) Ltd. 16 Bridge St, Llangefni, Anglesey. Nom. cap.: £5,000. Dirs.: R. Wilson, Mrs R. Wilson and Mrs A. Foster.

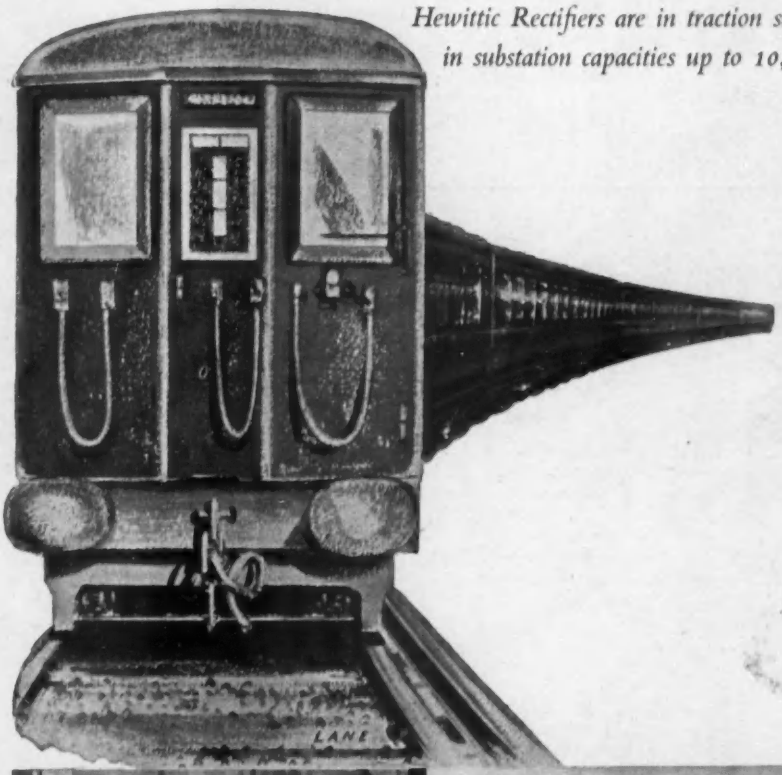
G. A. Curry and Co. Ltd. 169 Midland Rd, E.10. Manufacturers of and dealers in electrical and photographic equipment, etc. Nom. cap.: £3,000. Permt. dirs.: G. A. Curry and W. C. Thompson.

P. A. Baker Ltd. 101 Bartholomew St, Newbury, Berks. To take over business of retailer of electrical contracting appliances carried on at Trayzee, Compton, nr. Newbury, Berks, as "P. A. Baker." Nom. cap.: £100. Dirs.: P. A. Baker and Mrs J. O. Baker.

Hewittic Rectifiers are in course of replacing rotary converters at Waterloo Substation, supplying D.C. power to the eight main line tracks and serving all 21 platforms at Waterloo Railway Terminus, as well as supplying D.C. power to the Waterloo and City Railway.

117,500 kW of Hewittic Rectifiers 660/750 volts D.C. are being installed by the British Transport Commission in 28 substations on the Southern Region of British Railways.

Hewittic Rectifiers are in traction service in 18 countries in substation capacities up to 10,000 kW.



D.C. POWER

at Waterloo, one of the world's largest Railway Termini, is supplied through Hewittic Rectifiers

Left: Two of three 2,500 kW banks of Hewittic Rectifiers in service during the course of conversion of Waterloo Substation, and right: a view of the approaches to Waterloo station.

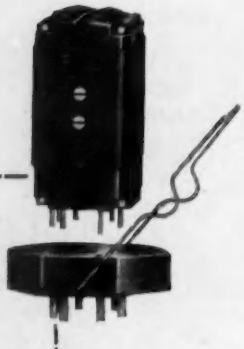
HACKBRIDGE AND HEWITTIC
ELECTRIC COMPANY LIMITED
WALTON-ON-THAMES · SURREY · ENGLAND
Phone: Walton-on-Thames 760 (8 lines) Grams & Cables: Electric, Walton-on-Thames

R 29

Weston *Moving Coil* Relays

FOR A WIDE VARIETY OF APPLICATIONS

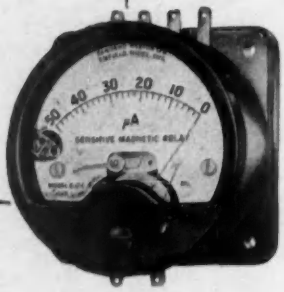
The simplicity and reliability of relay control has led to the ever increasing use of WESTON MOVING COIL RELAYS. Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should be accompanied by full particulars of both control and local circuits.



MODEL S115. A relay of extremely small size, functioning as an 'on-off' switch. Can be operated on a power input as low as 5 microwatts.

MODEL S54. A relay of extreme sensitivity with wide applications in Laboratory and Industrial Control. The high torque developed by the moving system ensures positive contact pressure.

MODEL S124. A highly sensitive relay with magnetic hold-on contacts having a higher rating than those of the above models.



SANGAMO WESTON LIMITED

ENFIELD · MIDDLESEX *Tel: Enfield 3434 (6 lines) & 1242 (6 lines)* *Grams: Sanwest, Enfield*

SANGAMO WESTON

Scottish Factory: Port Glasgow, Renfrewshire. Port Glasgow 41151
Branches: London, CHAncery 4971 Glasgow, Central 6208 Manchester, Central 7904 Newcastle-on-Tyne, Newcastle 26867 Leeds, Leeds 30867 Liverpool, Central 0230 Wolverhampton, Wolverhampton 21912 Nottingham, Nottingham 42403 Bristol, Bristol 21781 Southampton, Soton 23328 Brighton, Brighton 28497

SW/2

CLASSIFIED ADVERTISEMENTS

Advertisements should be sent to the Classified Advertisement Dept., Electrical Times, Sardinia House, Sardinia Street, London, W.C.2, before 10 a.m. on TUESDAY of the week of issue. Official Displayed Advertisements are charged at 32s. 6d. per inch, and all other classified advertisements at 2s. 6d. per line. Situations Wanted four insertions at twice the single insertion rate. Fee for Box Number and postage on replies 2s.

TENDERS INVITED

LITHERLAND URBAN DISTRICT COUNCIL

STREET LIGHTING
CONVERSION FROM GAS TO ELECTRICITY

FIRMS wishing to submit tenders for the supply of electrical apparatus and cable, extension brackets, lanterns, wall brackets, etc., required in connection with the conversion of 523 Gas lamps to Electric, may obtain details from the Engineer and Surveyor, Town Hall, Litherland, Liverpool 21, up to Friday, 19 Aug., 1955. (T 682)

RURAL DISTRICT COUNCIL OF PRESTON

STREET LIGHTING

TENDERS are invited from electrical contractors with experience in the erection of street lighting equipment for the installation of the following lighting schemes in the Parish of Penwortham:

Contract No. 1.

A class "A" scheme comprising 66 points on Liverpool Rd (A.59).

Contract No. 2.

(i) A class "A" scheme comprising 113 points on Leyland Rd;

(ii) A class "B" scheme comprising 75 points on Cop Lane, New Lane and Pope Lane.

(iii) A conversion scheme, utilising existing columns, of 232 points in other side streets.

Plans may be seen and Specifications and Bills of Quantities may be obtained upon application at the Council Offices, Guildhall St, Preston, on the deposit of a cheque payable to the Council for the sum of £2. 2s., which will be returned upon the receipt of a bona fide tender.

Notice is given that a Performance Bond may be required.

Tenders (which must be for the whole of the works comprised in each contract) enclosed in a plain sealed envelope endorsed "Street Lighting—Penwortham, Contract No. 1" (or Contract No. 2, as the case may be), should be forwarded so as to reach the undersigned not later than 9 a.m. on Saturday, 27 Aug., 1955.

The Council do not bind themselves to accept the lowest or any tender.

F. B. YOUNG,
Clerk and Chief Financial Officer.

Council Offices,
Guildhall St, Preston. (T 718)

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

33 kV OUTDOOR SWITCHGEAR AND ANCILLARY EQUIPMENT FOR DOUNREAY SUBSTATION, CAITHNESS

TENDERS are invited for the supply and erection of 33 kV Switchgear and Ancillary Equipment for the above mentioned Substation. Tender Documents may be obtained on application with a cheque for £2. 2s. (returnable), to the Engineers, Messrs Kennedy and Donkin, 12 Caxton St, London. S.W.1.

The Board do not bind themselves to accept the lowest or any Tender. H. W. Simpson, Secretary, 16 Rothesay Terr, Edinburgh 3. (T 719)

BOROUGH OF SCUNTHORPE

LIGHTING IMPROVEMENTS

TENDERS are invited for the supply of reinforced concrete columns, 140 W sodium and 80 W mercury discharge lanterns, and auxiliary gear and the erection and wiring of 14—25 ft columns and 142—15 ft columns.

Contract documents may be obtained from and the drawings inspected at the office of the Borough Surveyor, Mr Cyril Cooper, M.I.C.E., Comforts Ave, Scunthorpe, Lincs, on payment of a returnable deposit of £2. 2s.

Tenders in the envelopes provided must be received by the undersigned by 12 noon on Wednesday, 17 Aug., 1955.

W. P. ERRINGTON,
Town Clerk.

Municipal Offices,
34 High St, Scunthorpe.
25 July, 1955. (T 680)

BOROUGH OF REIGATE

CLASS A STREET LIGHTING SCHEME

TENDERS are invited for supply and erection of street lighting equipment on the Reigate-Hookwood Road A.217 and London-Castlefield Road A.2002. Specification and details from Borough Surveyor, Town Hall, Reigate. Sealed Tenders endorsed "Street Lighting" to undersigned by 27 Aug., 1955.

The Council does not bind itself to accept the lowest or any Tender.

HEBER DAVIES,
Town Clerk

Town Hall,
Reigate.
4 Aug., 1955. (T 683)

BOROUGH OF CHELTENHAM

TRUNK ROAD LIGHTING
BATH-LINCOLN TRUNK ROAD

TENDERS are invited for the supply and erection of a Group "A" Sodium discharge lighting installation as follows:

Bill No. 1. For the supply only of 123 No. 140 W non cut-off lanterns and lighting equipment.

Bill No. 2. For the supply and erection of 113 No. Steel Columns, together with fitting and wiring of tenderer's own lighting equipment.

Bill No. 3. As Bill No. 2 but for fitting and wiring of lighting equipment offered by another firm.

Specification and Bills of Quantities can be obtained from the undersigned on payment of a deposit of Three Guineas, which will be refunded on receipt of a bona fide tender, not subsequently withdrawn, and the return of all documents.

Drawings and Conditions of Contract can be inspected at this office during the usual working hours.

Tenders, together with fully priced Bills of Quantities are to be submitted in the envelope provided, to the Town Clerk, P.O. Box No. 12, Municipal Offices, Cheltenham, not later than first post, Monday 5 Sept., 1955.

The Council reserves the right to treat each Bill of Quantities as a separate tender, and does not bind itself to accept the lowest or any tender.

G. GOULD MARSLAND,
M.B.E., B.SC., M.I.C.E.
Borough Engineer.

P.O. Box 12,
Municipal Offices, Cheltenham. (T 681)

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

TENDERS are invited for the complete lighting and heating installation at the 24 MW Glascarnoch Power Station, Ross and Cromarty. Tender Documents may be obtained on application with a cheque for £2. 2s. (returnable) to the Engineers, Messrs. Merz and McLellan, 72a George St, Edinburgh 2. The Board do not bind themselves to accept the lowest or any Tender. H. W. Simpson, Secretary, 16 Rothesay Terrace, Edinburgh 3. (T 702)

CITY OF BELFAST

AUTOMATIC FIRE FIGHTING INSTALLATION; MEDIUM VOLTAGE SUB-STATION DISTRIBUTION BOARD

TENDERS are invited for:

(*a*) Supply, delivery and erection of Automatic Fire Fighting Installation (Water - Jet Emulsion - Forming Type). (Specification No. W.81.)

(*b*) Supply and delivery of Medium Voltage Substation Distribution Board (not Metalclad). (Specification No. W.82.)

Forms of Tender and Specifications may be obtained at the Electricity Department, East Bridge St, Belfast.

Each tender in sealed envelope marked "Tender for . . ., Electricity Committee," and endorsed with the name and address of the tenderer, must reach the undersigned not later than 4 p.m. on Friday, 26 Aug., 1955.

An official receipt must be obtained for each tender delivered by hand. Tenders sent by post should be registered. The lowest or any tender will not necessarily be accepted.

JOHN DUNLOP,
Town Clerk.

City Hall, Belfast,
P.O. Box No. 234.
23 July, 1955. (T 670)

APPOINTMENTS VACANT

Engagement of persons must be made through a Local Labour Office or Scheduled Employment Agency, if the applicant is a man aged 18–64, or a woman aged 18–59; unless the person concerned is excepted or the employment is in a managerial or professional capacity, or is otherwise excepted from the provisions of the Notification of Vacancies Order, 1952.

CENTRAL ELECTRICITY AUTHORITY
Southern Division

APPLICATIONS are invited for the following position at Earley Generating Station, Reading:

COAL HANDLING FOREMAN

Applicants should have a thorough knowledge of generating station coal plant and should be capable of organising, under supervision, the marshalling and discharging of railborne coal.

Salary N.J.I.C., Schedule E, Grade 3, £545 plus £70 per annum shift allowance=£615.

Applications giving full details of age, qualifications, experience and present position should reach the Station Superintendent, Earley Generating Station, Shepherds House Lane, Earley, Reading, by 17 Aug., 1955. PSL/DR.

25 July, 1955. (T 664)

LONDON ELECTRICITY BOARD

GENERAL ASSISTANT ENGINEERS

APPLICATIONS are invited for the above positions in the Walthamstow and West Ham districts of the Board's North Eastern Sub-Area.

Applicants should have had a sound technical education preferably to Higher National Certificate standard. Initially the successful candidates will be required to undertake duties, including standby, in connection with distribution systems.

Pending determination as to the grading and salary applicable to the posts within the National Joint Board agreement, the provisional minimum salaries will be £500 per annum, inclusive of London Allowance.

Application forms obtainable from Personnel Officer, 46/7 New Broad St, London, E.C.2, to be returned completed by 16 Aug., 1955. Please enclose addressed envelope and quote ref.: V/2006/7/T. (T 691)

LONDON ELECTRICITY BOARD

SENIOR AND ENGINEERING DRAUGHTSMEN

APPLICATIONS are invited for the following vacancies. These posts are permanent and superannuable and they are graded under Schedule D of the National Joint Board agreement.

ENGINEERING DRAUGHTSMEN

Commencing salaries dependent upon qualifications and experience within Grade 6, £535. 10s./£661. 10s. per annum, inclusive of London Allowance.

Hampstead/Willesden District

(DESIGN AND PLANNING)
Vacancy No. V/1972/T

Applicants should have had a good general and technical education in electrical engineering and building construction, and experience in a mains records office dealing with systems of all voltages up to 11 kV.

North Eastern Sub-Area

(BASED AT STRATFORD, E.15)
Vacancy No. V/2012/T

Candidates should have had a good general and technical education and be experienced in one or more of the following subjects: engineering drawing; plant layout in substations; layouts and site plans of mains work; electrical diagrams.

St. Marylebone/St. Pancras District

(DESIGN AND PLANNING)
Vacancy No. V/1967/T

Applicants should have had a good general and technical education in electrical engineering and building construction, and experience in a mains records office dealing with systems of all voltages up to 11 kV.

Western Sub-Area

(AT ECCLESTON PLACE, S.W.1)
Vacancy No. V/1947/T

Candidates must have had a good general and technical education up to National Certificate standard, and must be neat draughtsmen. They should be conversant with the layout of switchgear and transformers and associated equipment up to 11 kV for small substations. They should also be conversant with electrical diagrams, mains records, and similar work. Those with good experience in surveying and planning of mains networks would be considered even if having little experience of substation layouts.

Southern Sub-Area

(BASED AT BECKENHAM, KENT)
Vacancy No. V/1980/T

Candidates should have had a good general and technical education up to Ordinary National Certificate standard, be neat and capable draughtsmen and experienced in one or more of the following subjects: drawing office routine, electrical diagrams, layout of plant in transformer chambers, mains survey and recording of mains work.

Chief Engineer's Department

(AT STAMFORD ST., S.E.1)
Vacancy No. V/1989/T

Candidates should be experienced in surveying E.H.V. cable routes and have had good experience in making accurate surveys of cable routes during the laying of E.H.V. cables, taking information and sketches on site and producing final drawings.

Chief Engineer's Department

(AT STAMFORD ST., S.E.1)
Vacancy No. V/1989/T

Applicants, required for plant layout, should preferably have served an engineering apprenticeship and have had technical training to Ordinary National Certificate level, together with experience in the layout of transforming plant, H.V. switchgear and cables up to 66 kV. (In this instance an appointment may be made within Grade 5, £672/£777 per annum inclusive.)

SENIOR DRAUGHTSMEN

Commencing salaries dependent upon qualifications and experience within Grade 5, £672/£777 per annum, inclusive of London Allowance.

Contracting Section

(AT STRATFORD PLACE, W.1)
Vacancy No. V/1986/T

Applicants should be capable of complet-

continued in next column

continued from previous column

ing layouts of plant and associated cabling for large industrial installations.

Hampstead/Willesden District

(AT HAMPSTEAD, N.W.3)
Vacancy No. V/1998/T

Applicants should have had a good general and technical education in electrical engineering and building construction, and experience in a mains records office dealing with systems of all voltages up to 11 kV. In addition, the applicant should be capable of supervising Engineering Draughtsmen and/or Junior Draughtsmen, if required.

St. Marylebone St. Pancras District

(AT AYBROOK ST, W.1.)
Vacancy No. V/2001/T

Applicants should have had a good general and technical education in electrical engineering and building construction, and experience in a mains records office dealing with systems of all voltages up to 11 kV. In addition, the applicant should be capable of supervising Engineering Draughtsmen and/or Junior Draughtsmen, if required.

Application forms for the foregoing vacancies are obtainable from the Personnel Officer, 46/7 New Broad St, London, E.C.2. Please enclose addressed envelope and quote reference No. of vacancy preferred.T 351)

EASTERN ELECTRICITY BOARD

Essex Sub-Area

GENERAL ASSISTANT ENGINEERS

CANDIDATES should have had a sound technical education to Higher National Certificate standard and some experience of H.V. and L.V. distribution systems.

Salary—N.J.B. Class K, Grades 18 to 14, within the range £475/£680, plus London Weighting, the commencing grade and salary will be according to experience.

The successful candidates will be required to contribute to a superannuation scheme and may be required to undergo a medical examination.

Applications by letter, within 14 days, to the Engineer, Essex Sub-Area, Eastern Electricity Board, Millfield, Bentley, Nr. Brentwood, Essex. (T 686)

MIDLANDS ELECTRICITY BOARD

APPLICATIONS are invited for the following superannuable posts:

Central Gloucestershire Sub-Area

DISTRICT COMMERCIAL ENGINEER (CHELTENHAM)

Applicants should have had extensive practical experience in industrial, agricultural and domestic load development in rural and urban areas including preparation of specifications and the completion of tenders for large wiring contracts, supervision of contracting department, public lighting, sales of electrical equipment and service and advice to consumers. Technical qualifications desirable. Salary £840/£900 per annum (N.J.B. Class E, Grade 4).

Apply, in writing, within fourteen days, stating age, qualifications and experience, present position and salary to Mr S. Raybould, Sub-Area Manager, Midlands Electricity Board, 126 London Rd, Gloucester.

South Staffs and North Worcs Sub-Area

THIRD ASSISTANT DISTRICT COMMERCIAL ENGINEER (STOURBRIDGE)

Applicants should have had a sound technical training with practical experience in the sale and installation of domestic and commercial electrical equipment and the wiring associated therewith. Experience of estimating for installation work and the possession of appropriate technical qualifications will be considered an advantage. The duties will include the supervision of contracting work, advising consumers in respect of new supplies, extensions, alterations and estimating for same. Salary £635/£680 per annum (N.J.B. Class F, Grade 10).

Apply, in writing, within fourteen days, stating age, qualifications and experience, present postion and salary to Mr T. G. Keeler, Sub-Area Manager (Ref. CW), Midlands Electricity Board, P.O. Box No. 9, Toll End Rd, Tipton.

A. STEPHENS,
Secretary.
(T 687)

CENTRAL ELECTRICITY AUTHORITY

London Division

APPLICATIONS are invited for the following superannuable posts. Conditions of service in accordance with N.J.B. Agreement, Schedule A. Salary includes London Allowance. Qualifications entitling to Graduate Membership of the I.E.E. or I.Mech.E. for posts (*a*) and Corporate Membership for post (*b*) an advantage.

(*a*) ASSISTANT SHIFT CHARGE ENGINEER—BOW GENERATING STATION

Vacancy No. 55/588

Applicants should have served an apprenticeship and obtained H.N.C. in Electrical and/or Mechanical Engineering or equivalent, and should have had experience in the operation of boiler and turbine plant in generating stations. Salary—Class F, Grade 9=£708. 15s. per annum.

(*b*) DEPUTY STATION SUPERINTENDENT ST. MARYLEBONE GENERATING STATION

Vacancy No. 55/589

Applicants should have a sound technical training and organising ability, and wide experience in the efficient operation and maintenance of Power Station plant. A lively sense of responsibility in Management/Employee relations essential. Salary—Class E, Grade 3=£945 per annum.

(*a*) STATION SHIFT CONTROL ENGINEER—WEST HAM GENERATING STATION

Vacancy No. 55/590

Applicants should have a sound technical training and practical experience in the control and operation of steam generating plant and main switchgear in modern generating station. Salary—Class H, Grade 10=£750. 15s. per annum.

Applications, quoting vacancy number, may be made on form obtainable from Divisional Secretary, Central Electricity Authority, London Division, P.O. Box 136, Generation House, Great Portland St, W.1, and be received within 14 days of this advertisement. (T 673)

AIR MINISTRY

require STATION ENGINEERS (G.D.) and STATION ENGINEERS (MECH.) at Royal Air Force and Ministry of Transport and Civil Aviation stations. Qualifications required (*a*) Ordinary National Certificate in Electrical or Mechanical Engineering or show that an equivalent standard of technical education has been reached. (*b*) recognised apprenticeship in electrical or mechanical engineering with firm or establishment of good repute, (*c*) three years' employment in electrical or mechanical engineering preferably on operation and maintenance of mine, factory or workshop plant and services. Preference will be given to applicants who have had supervisory duties subsequent to (*b*) and (*c*). Work will consist of installation, operation and maintenance of high and medium voltage electrical distribution systems, electrical installations, generating plant, steam and hot water heating systems and miscellaneous works plant, tools and equipment. Commencing salary according to age, qualifications and experience on range from £535/£772. Liability for tours of duty overseas for which special allowance payable in addition to higher salary. Appointments non-pensionable and experience to AB.1255, Appointments Officer, Ministry of Labour and National Service, 1-6 Tavistock Sq, W.C.1. No original Testimonials should be sent. Only candidates selected for interview will be advised. (T 409)

CENTRAL ELECTRICITY AUTHORITY

South Western Division

STATION SHIFT CONTROL ENGINEERS required at Portishead "B" Power Station

Superannuation Scheme. Salary N.J.B. Class J, Grade 10, £755/£800.

Applicants should possess good technical qualifications, and have had training and experience in the control and operation of steam generating plant and main switchgear.

Applications on Form A.E.6/ACT, obtainable from the Divisional Secretary, 26 Oakfield Rd, Bristol 8, should be completed and returned by 17 Aug., 1955. (T 674)

SOUTH OF SCOTLAND ELECTRICITY BOARD

Lanarkshire Area

ENGINEERING APPOINTMENTS

APPLICATIONS are invited for the undernoted Engineering Appointments. The Salaries and Conditions of Service for each appointment will be in accordance with the National Joint Board Agreement, Schedule A, and the present Classification, Grading and Salary will be as detailed below. The salaries will be subject to the statutory deductions including superannuation. Applicants for each vacancy should possess the necessary technical qualifications.

AREA TRANSFORMER AND PROTECTION TEST DEPARTMENT

(1) ONE FOURTH ASSISTANT ENGINEER (TEST)

Applicants should have had a sound engineering training with some subsequent experience in the testing, repair and maintenance of Feeder Protection Schemes. The present Classification and Grading is K.13, salary £675/£720 per annum.

DISTRICTS

(2) TWO THIRD ASSISTANT DISTRICT ENGINEERS

Present Classification

District	*and Grading*	*Present Salary*
(*a*) Coatbridge	F.9	£675/£720 p.a.
(*b*) Hamilton	E.9	£635/£680 p.a.

Applicants should have had a sound engineering training with some subsequent experience in the maintenance and operation of H.V. and L.V. Distribution Systems.

The successful candidates will require to reside within a reasonable distance of their respective District Offices and to take part in the standby duty rota.

Application forms, which may be obtained from the undersigned, should be forwarded to this office within 14 days of the date of this advertisement.

DUGALD SMITH,
Manager.

137 Almada St,
Hamilton. (T 663)

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

Orkney Area

APPLICATIONS are invited for the post of ASSISTANT ENGINEER on distribution work in the Orkney area.

Salary and conditions in accordance with N.J.B. Agreement Class B, Grade 5, £675 x £15—£720.

A four-apartment bungalow could be made available if required.

Applicants with suitable qualifications and experience should apply to:

R. F. WALLS,
Area Manager.

Junction Rd,
Kirkwall, Orkney. (T 665)

THE NORTH WESTERN ELECTRICITY BOARD

FIRST ASSISTANT DISTRICT COMMERCIAL ENGINEER, PENRITH DISTRICT

DUTIES will include assisting the District Commercial Engineer in dealing with consumers' requirements and enquiries on all matters including sale and installation of apparatus, repairs and maintenance, emergency service and tariffs, new supplies and development in urban and rural areas, control of workshops and service centres, and preparation of specifications and estimates.

Salary Scale: £755 x £15—£800 per annum. Grade D.5. N.J.B. Conditions.

GENERAL ASSISTANT ENGINEER (TESTING) SUB AREA ENGINEER'S DEPARTMENT, CARLISLE TESTING STATION

The successful applicant will be required to assist in general testing duties (meters and system protection) in the Testing Department, Carlisle.

Applicants should possess the H.N.C. in Electrical Engineering, but consideration will be given to applicants in possession of the O.N.C. who are progressing towards obtaining their H.N.C.

Salary Scale: £475 x £15—£520 per annum. Grade J.17. N.J.B. Conditions.

Applications for the above posts to Sub-Area Manager, No. 6 Sub-Area, the North Western Electricity Board, Castle Green, Kendal, by 13 Aug., 1955. (T 703)

SOUTH EASTERN ELECTRICITY BOARD

FOURTH ASSISTANT DISTRICT ENGINEER

Reigate and Horley District

SALARY £595 x £15—£640 under N.J.B. Class E, Grade 10. Superannuable. Applicants should be suitably qualified and have had training and experience in the planning, construction, operation and maintenance of overhead and underground distribution systems up to 11 kV. The position will entail standby duties.

Applications, naming 2 referees, on forms from H. F. Gill, District Manager, Reigate and Horley District, SEEBoard, Electric House, West Hill, Oxted, by 17 Aug., 1955.

CARTOGRAPHIC DRAUGHTSMAN

Tunbridge Wells District

Salary £525 x £20—£585 under N.J.C. Grade 2. Applicants must have had sound Drawing Office experience in mains records and reproduction of ordnance survey maps. Knowledge of overhead line survey work would be an advantage.

Applications to T. W. Dann, M.ENG., M.I.E.E., District Manager, SEEBoard, Town Hall, Tunbridge Wells, by 17 Aug., 1955.

A. L. BURNELL,
Secretary.
(T 690)

YORKSHIRE ELECTRICITY BOARD

No. 3 (Sheffield) Sub-Area

Sheffield North District

THIRD ASSISTANT DISTRICT ENGINEER

APPLICANTS should preferably have technical qualifications equivalent to Corporate Membership of the Institution of Electrical Engineers, and must have had experience in construction, operation and maintenance of 11 kV and L.V. overhead and underground distribution systems including substation equipment.

The successful candidate will be expected to supervise construction and maintenance work, and carry out operational duties on 11 kV and L.V. overhead and underground mains and substations in a district containing a heavy industrial and densely developed residential area surrounded by a rural area.

Salary—N.J.B. Class K, Grade 9, £840/£20/£900 per annum.

Applications, giving full details of age, qualifications and experience, together with the names of two referees, should be forwarded to the Manager, No. 3 (Sheffield) Sub-Area, Yorkshire Electricity Board, Commercial St, Sheffield, not later than 18 Aug., 1955.

No. 1 (Bradford) Sub-Area

FOURTH ASSISTANT ENGINEER (DISTRIBUTION DESIGN)

Applicants should possess the Higher National Certificate in Electrical Engineering or equivalent technical qualifications. A sound background of experience in the construction and maintenance of high and medium voltage A.C. systems is more essential, for this post, than extended knowledge of estimating and design, although some experience of the latter will be an advantage.

Salary—N.J.B. Class K, Grade 13, £675/£15/£720 per annum.

Applications, giving full details of age, qualifications and experience, together with the names of two referees, should be forwarded to the Manager, No. 1 (Bradford) Sub-Area, Yorkshire Electricity Board, 45-53 Sunbridge Rd, Bradford, not later than 18 Aug., 1955. (T 688)

CENTRAL ELECTRICITY AUTHORITY

South Wales Division

Vacancy No. 81/55

APPLICATIONS invited for superannuable N.J.B. appointment of STATION SHIFT CONTROL ENGINEER at Tir John Power Station.

Salary: H.10—£715 x £15—£760 per annum.

H.N.C. and experience in power station control room desirable.

Application forms obtainable from Secretary, South Wales Division, Central Electricity Authority, Twyn-y-fedwen Rd, Gabalfa, Cardiff, to be returned by 15 Aug., 1955. (T 666)

SOUTHERN ELECTRICITY BOARD

PLANNING ENGINEER

ISLE OF WIGHT District of No. 3 (Portsmouth) Sub-Area. Salary N.J.B. Class E, Grade 7 (£715 x £15—£760 per annum). N.J.B. Conditions of Service.

The duties of the post will be to assist in the preparation of schemes and estimates for extensions of and reinforcement to overhead and underground H.V. and L.V. networks and substations of all types operating at voltages up to 33,000 V. Applicants must possess technical qualifications up to A.M.I.E.E. standard.

Applications on forms obtainable from the Sub-Area Secretary, Lower Drayton Lane, Cosham, Portsmouth, and returned to him in envelopes suitably endorsed, not later than 19 Aug., 1955.

ASSISTANT ENGINEER (PLANNING)

Chichester District of No. 3 (Portsmouth) Sub-Area. Salary N.J.B. Class E, Grade 10 (£595 x £15—£640 per annum). N.J.B. Conditions of Service.

The duties of the post will be to assist the Planning Engineer in the preparation of schemes and estimates for extensions of and reinforcement to overhead and underground H.V. and L.V. networks, and will be required to undertake standby duties if necessary. The possession of suitable technical qualifications will be an advantage.

Applications on forms obtainable from the Sub-Area Secretary, Lower Drayton Lane, Cosham, Portsmouth, and returned to him in envelopes suitably endorsed, not later than 19 Aug., 1955.

ASSISTANT ENGINEER (LOCAL)

Swindon District of No. 2 (Newbury) Sub-Area located at Cirencester. Salary N.J.B. Class F, Grade 11, commencing at £595 per annum and rising to £640 per annum maximum. N.J.B. Conditions of Service.

Applicants should have experience in the design, construction, operation and maintenance of H.V. and L.V. overhead and underground distribution systems, substation plant and distribution equipment, and possess suitable technical qualifications. The appointment will involve standby duties.

Applications on forms obtainable from the Sub-Area Secretary, 7 Oxford Rd, Newbury, and returned to him in envelopes suitably endorsed, not later than 19 Aug., 1955.

ASSISTANT ENGINEER (GENERAL)

Southampton District of No. 4 (Bournemouth) Sub-Area. Salary N.J.B. Class F, Grade 12 (£555 x £15—£600 per annum). N.J.B. Conditions of Service.

Applicants should be conversant with the design, construction, operation and maintenance of H.V. and L.V. overhead and underground distribution systems, substation plant and distribution equipment. The possession of suitable technical qualifications will be an advantage. The successful candidate will mainly be required to assist the Planning Engineer.

Applications on forms obtainable from the Sub-Area Secretary, 1 Priory Rd, Bournemouth, and returned to him in envelopes suitably endorsed, not later than 19 Aug., 1955.

The successful candidates for the above appointments will be required to contribute to the C.E.A. and Area Boards' Superannuation Scheme, if eligible. (T 692)

AIR MINISTRY

Works Designs Branch

require in London and Provinces (with liability for overseas service) ELECTRICAL ENGINEERING DRAUGHTSMEN experienced in preparation of schemes for illumination and electrical equipment of buildings or in electrical distribution H.V. and M.V. Technical training to O.N.C. standard or equivalent an advantage. Salaries up to £810 per annum, starting pay based on age, qualifications and experience. Paid overtime. Posts non-pensionable with long-term possibilities. Natural-born British subjects only. Write stating age, qualifications, employment details including type of work done to any Employment Exchange, quoting Order No. Borough 2307. (T 684)

SOUTH OF SCOTLAND ELECTRICITY BOARD
Glasgow Area

APPLICATIONS are invited for the appointment of SENIOR ASSISTANT ENGINEER (Operation and Maintenance) in this Area.

Applicants should have had considerable general experience of public electricity supply in densely loaded commercial, residential and industrial areas and be capable of taking charge of the operation and maintenance of the 300 MW distribution system (33, 20, 6·6 kV and L.V.) in Glasgow and of supervising the work of the District Engineers.

Corporate Membership of the Institution of Electrical Engineers would be desirable.

Salary—N.J.B. Class K, Grade 4 (£1,195/£1,300 per annum).

The post is superannuable and the successful candidate may be subject to medical examination.

He will also be required to reside within a reasonable distance of the Area Headquarters.

Form of application, which may be obtained from the undersigned, should be completed and returned not later than 10 Sept., 1955.

A. KELSO,
Manager.

P.O. Box 6,
75 Waterloo St,
Glasgow C.2. (T 717)

CENTRAL ELECTRICITY AUTHORITY
South Western Division

VACANCIES—GENERATION CONSTRUCTION DEPARTMENT, FEEDER ROAD, BRISTOL, 2

(*a*) ENGINEERING DRAUGHTSMEN (Mechanical).
N.J.B. Schedule D, Grade 6, £510/£630.

(*b*) THIRD ASSISTANT ENGINEER (Mechanical) N.J.B. 4AX/CX, £750/£925. Superannuation Scheme.

Applicants for (*a*) should have had a sound technical training and good general engineering experience preferably in connection with power station equipment.

For (*b*) should have good mechanical engineering training with experience in Power Station equipment, preferably including design work and preparation of specifications. H.N.C. or equivalent desirable.

Applications on Form A.E.6/ACT, obtainable from the Divisional Secretary, 26 Oakfield Rd, Bristol 8, should be completed and returned by 20 Aug., 1955. (T 705)

CITY ARCHITECT'S DEPARTMENT
Manchester

APPLICATIONS are invited for the appointment of an ELECTRICAL ENGINEERING ASSISTANT on the permanent staff. Salary in accordance with APT. Grade 1/11 of the National Scheme of Service Conditions, i.e. £500 rising to £640 per annum. Commencing salary according to qualifications and experience. Candidates must have a thorough knowledge of electric lighting and power installations in all classes of buildings and be experienced in the supervision of work in progress.

Form of application may be obtained from the City Architect, Town Hall, Manchester 2, and should be returned to the same address by 17 Aug., 1955. Canvassing is prohibited. (T 714)

CENTRAL ELECTRICITY AUTHORITY
Midlands Division

SECOND ASSISTANT STATION CHEMIST is required at Nechells "A" and "B" Power Stations. N.J.B. service conditions, superannuable appointment, salary within Schedule "A," Grade K11, £755/£800 per annum.

Applicants should preferably hold Higher National Certificate in Chemistry, and should have had experience in the analysis of fuels, waters and oils and be conversant with water treatment as applied to modern high pressure power stations.

Apply, quoting Vacancy No. 21MD, on form AE6, available from the Establishments Officer, 53 Wake Green Rd, Moseley, Birmingham 13, by 20 Aug., 1955. (T 711)

MERSEYSIDE AND NORTH WALES ELECTRICITY BOARD

APPLICATIONS are invited for the following appointments, which are superannuable and subject to medical examination, in the Board's No. 1 Sub-Area:

(1) FIRST ASSISTANT DISTRICT ENGINEER in the Southport District.
Salary £790/£850 per annum (N.J.B. E/5).

(2) SECTION ENGINEER in the Liverpool North District.
Salary £840/£900 per annum (N.J.B. H/7).

For posts (1) and (2) applicants should have had experience in the construction, operation and maintenance of systems up to and including 33 kV, and have the appropriate technical qualifications.

(3) ASSISTANT SECTION ENGINEER in the Southport District.
Salary within the range £635/£680 per annum (N.J.B. E/9).

Applicants must have received a thorough technical training, and have the appropriate technical qualifications. Duties will be concerned with the construction and operation of h.v. and m.v. networks, and substations.

For all posts, application forms are obtainable from the Manager, No. 1 Sub-Area, 24 Hatton Garden, Liverpool 3. Closing date: 22 Aug., 1955. (T 713)

UGANDA ELECTRICITY BOARD

APPLICATIONS are invited for permanent posts overseas as ASSISTANT ELECTRICAL ENGINEERS to meet the growth of the Board's system.

Experience in construction, operation and maintenance (preferably all three departments) of a public electricity supply system, including overhead lines and substations up to at least 33 kV, is essential; experience at higher voltages is desirable.

Applicants for all appointments should either be Corporate Members of the Institution of Electrical Engineers or should have technical qualifications leading to that status. Posts are vacant for those with considerable experience and for those with less, in the latter case, Graduate and Student Members would be eligible.

Salaries according to age and experience will be within the following annual incremental scales:

Corporate Members—£1,020 x £30—£1,260 with proficiency bar and thereafter x £30—£1,380 per annum, otherwise £990 x £30—£1,110 with proficiency bar and thereafter x £30—£1,260 per annum.

Uganda has a pleasant climate, income tax is moderate and the salaries which have recently been revised are very reasonable in relation to the cost of living.

Free passages, partly furnished accommodation, medical and dental treatment. Vacation leave on full pay after three years' service.

Application forms and further information may be obtained from the London Representative, Uganda Electricity Board, 27 Regent St, London, S.W.1.

C. R. WESTLAKE,
Chairman.
(T 638)

CENTRAL ELECTRICITY AUTHORITY
Midlands Division

SECOND ASSISTANT ENGINEER (Mechanical) is required in the Generation Construction Department at Wolverhampton. N.J.B. service conditions, superannuable appointment, salary within Schedule C, Grade 2, of the Agreement, commencing in range £950/£1,075 and ultimately rising to £1,165 per annum.

Applicants should have experience in the design and installation of boilers, turbo-alternators and other mechanical equipment associated with modern generating stations; also in the preparation of specifications and reports on tenders. Appropriate technical qualifications will be an advantage.

Apply, quoting Vacancy No. 25MD on form AE6, available from the Establishments Officer, 53 Wake Green Rd, Moseley, Birmingham 13, by 22 Aug., 1955. (T 708)

CENTRAL ELECTRICITY AUTHORITY
South Western Division

FITTER (Electrical)—49d. per hour.
LINESMAN (over 60,000 V) 49d. per hour

required in the Transmission Section, at Lockleaze Substation, Bristol.

44-hour week. N.J.I.C. Conditions of Employment.

Written applications should be addressed to the Section Engineer, Central Electricity Authority, South Western Division, Wapley, Near Chipping Sodbury, Gloucester. (T 675)

SOUTH OF SCOTLAND ELECTRICITY BOARD
Eothians Area

SENIOR ASSISTANT ENGINEER
(PLANNING AND DEVELOPMENT)

APPLICATIONS are invited for the above appointment at Area Headquarters, Musselburgh. Salary and Conditions of Service will be in accordance with the National Joint Board Agreement, Grade 4, Class G, £975/£1,050 per annum.

Applicants should have had experience in planning extensions to rural and urban networks up to 33 kV. Previous construction experience would be an advantage. Corporate Membership of the Institution of Electrical Engineers is preferable.

Application forms, which may be obtained from the undersigned, should be lodged within fourteen days of the date of this advertisement.

G. F. MOORE,
Manager.

12 High St,
Musselburgh. (T 636)

CENTRAL ELECTRICITY AUTHORITY
Midlands Division

ASSISTANT SHIFT CHARGE ENGINEER is required at Ocker Hill Generating Station. N.J.B. service conditions, superannuable appointment, salary within Schedule A, Grade F9, £675/£720 per annum.

A sound technical training and practical experience in the control and operation of steam generating plant and main switchgear are required. Appropriate qualifications an advantage.

Apply, quoting Vacancy No. 20MD on form AE6, available from the Establishments Officer, 53 Wake Green Rd, Moseley, Birmingham 13, by 20 Aug., 1955. (T 710)

ELECTRICITY SUPPLY BOARD, IRELAND

VACANCIES FOR:

A. MECHANICAL OR ELECTRICAL ENGINEERS

B. GRADUATES OF I.MECH.E. OR I.E.E.

(*a*) VACANCIES exist in the Board's Engineering Departments—Generation, Transmission, Distribution, Operation and Sales—for qualified electrical/mechanical engineers. The salary scale including cost of living bonus is £540/£980 per annum, with higher entry point for those with suitable post-graduation experience or special qualifications. The Board's extensive programme of expansion in all its engineering Departments offers favourable opportunities of early advancement to a higher grade.

(*b*) Vacancies also exist for which Graduates of the Institutions of Mechanical or Electrical Engineers will be considered, salary scale and starting salary being related to experience.

Applications, with details of age, qualifications and experience should reach the Personnel Officer, 27 Lower Fitzwilliam St, not later than 20 Aug., 1955.

PATRICK J. DEMPSEY,
Secretary.
(T 707)

CENTRAL ELECTRICITY AUTHORITY
North West, Merseyside and N. Wales Division

VACANCY No. E.192/270/T.—MAINTENANCE ENGINEER (Mech.), Westwood Generating Station. Salary £840/£900 (G.6).

Applications to Divisional Secretary, Central Electricity House, 825 Wilmslow Rd, Manchester 20, before 13 Aug. Quote vacancy No. (T 706)

NOTTINGHAMSHIRE COUNTY COUNCIL
County Architect's Department

APPOINTMENT OF STAFF

APPLICATIONS are invited for the appointment of TRACERS (male or female) in the County Architect's Department.

Salary scale in accordance with the Higher General Division of the National Scale (max. £475 per annum). Commencing salary in accordance with experience and qualifications.

Duties will consist of the preparation of final layouts for heating and hot water, ventilation schemes and boiler-house plants, and for electrical installations. Previous experience in an engineer's office will be an advantage and neat and accurate draughtsmanship is essential.

Forms of application may be obtained from Donald Gibson, County Architect, County Hall, Trent Bridge, Nottingham, to whom they should be returned as soon as possible and in any event not later than 26 Aug., 1955. A. R. DAVIS,
Shire Hall, Clerk of the County Council.
Nottingham. (T 667)

SOUTH OF SCOTLAND ELECTRICITY BOARD
Lanarkshire Area

ENGINEERING APPOINTMENTS

APPLICATIONS are invited for the undernoted Engineering Appointments. The Salaries and Conditions of Service for each appointment will be in accordance with the National Joint Board Agreement, Schedule A; the present Classification Grading and Salary being as detailed below. The salaries will be subject to the statutory deductions including superannuation.

Applicants for each vacancy should possess the necessary technical qualifications.

TWO SECOND ASSISTANT DISTRICT ENGINEERS

(*a*) District—Uddingston. Present Classification and Grading F7. Salary £755/£800 per annum.

(*b*) District—Hamilton. Present Classification and Grading E7. Salary £715/£760 per annum.

The successful applicants for these two appointments will require to reside within a reasonable distance of their respective District Offices.

GENERAL ASSISTANT ENGINEER (MOTHERWELL SWITCH HOUSE)

Applicants should have had experience in switching operations associated with a large H.V. network, including the operation, under instructions, of 132 kV switchgear and in the operation of tap changing gear. They should also be conversant with the daily routine work of a large H.V. switchboard.

The present classification and grading is F12, Salary £555/£600 per annum.

Application forms, which may be had from the undersigned, should be forwarded to this office within 14 days of the date of this advertisement. DUGALD SMITH,
137 Almada St, Manager.
Hamilton. (T 715)

CENTRAL ELECTRICITY AUTHORITY
Eastern Division

APPLICATIONS are invited for the following appointments at Goldington Generating Station, near Bedford:

MAINTENANCE ENGINEER (MECHANICAL)

Salary Class G, Grade 6, £840 x £20—£900 per annum, eventually rising to Class H, £900 x £25—£975 per annum.

Applicants should have served an apprenticeship and have had experience with the maintenance of modern pulverised fuel-fired boilers, turbines and coal and ash handling plants. Operating and supervisory experience and suitable technical qualifications will be an advantage.

MAINTENANCE ENGINEER (ELECTRICAL)

Salary Class G, Grade 6, £840 x £70—£900 per annum, eventually rising to Class H, £900 x £25—£975 per annum.

Applicants should have served an apprenticeship and possess good experience in the maintenance of generating station electrical plant, including high voltage switchgear and instruments.

Previous generating station operating ex-

continued in next column

continued from previous column

perience and appropriate technical qualifications will be an advantage.

ASSISTANT ENGINEER (INSTRUMENTS)

Salary Class G, Grades 12-10, £595 x £15—£640 per annum to £675 x £15—£720 per annum, depending upon experience and qualifications. Eventually rising to Class H, £635 x £15—£680 per annum to £715 x £15—£760 per annum.

Applicants should have had a sound technical training and good practical experience in the construction, repair and testing of generating station instruments and automatic controls for mechanical services.

Applications are also invited for the following appointments:

GENERAL ASSISTANT ENGINEER
BRIMSDOWN GENERATING STATION

Salary within the range of Class J, Grade 17, £475 x £15—£520 per annum plus London Weighting, and Grade 14, £595 x £15—£640 per annum plus London Weighting, depending on duties and responsibilities.

Duties, including periods of Shift Duty, involve assisting in the Electrical Control Room and experience in the technical operation of electrical, boiler house and turbine house plant, testing, etc., and provide a suitable basis for promotion to higher technical grades.

Previous experience in a Generating Station and/or technical training to the standard of the Ordinary National Certificate or its equivalent will be an advantage.

GENERAL ASSISTANT ENGINEER
LITTLE BARFORD GENERATING STATION

Salary Class G, Grade 15, £475 x £15—£520 per annum.

The duties of the successful applicant will include assisting in the Control Room on shift and other operation and investigation duties. Preference will be given to applicants who have had previous experience in a Generating Station and who have reached the standard of the Ordinary National Certificate in Electrical Engineering or its equivalent.

STATION SHIFT CONTROL ENGINEER
LETCHWORTH GENERATING STATION

Salary Class E, Grade 10, £595 x £15—£640 per annum.

Applicants should have reached the standard of Ordinary National Certificate in Electrical Engineering or its equivalent, have experience in the operation of a Switchboard at a Generating Station and be fully conversant with High Voltage Switching operations and protective systems. A knowledge of the operation of various types of D.C. Converting Plant will be an advantage.

Applications, stating age, details of qualifications and experience should be sent to the Controller, Central Electricity Authority, Eastern Division, Northmet House, Southgate, N.14, not later than 20 Aug., 1955.
W. N. C. CLINCH,
Controller.
(T 689)

SOUTH OF SCOTLAND ELECTRICITY BOARD

require an ASSISTANT SHIFT CHARGE ENGINEER at Dalmarnock Power Station, Glasgow.

The post will be superannuable and the salary in accordance with Class J, Grade 9, of the National Joint Board will be at the commencing rate of £790 per annum.

Apply in writing to the Secretary, South of Scotland Electricity Board, 351 Sauchiehall St, Glasgow, before 25 Aug., 1955. (T 716)

CENTRAL ELECTRICITY AUTHORITY
Midlands Division

STATION SHIFT CONTROL ENGINEER is required at Hams Hall "B" Power Station, Birmingham. N.J.B. service conditions, superannuable appointment, salary within Schedule A of the Agreement, Grade K10, commencing at £790 per annum.

A sound technical training and practical experience in the control of steam generating plant and main switchgear are required. Appropriate technical qualifications an advantage.

Apply, quoting Vacancy No. 32MD on form AE6, available from the Establishments Officer, 53 Wake Green Rd, Moseley, Birmingham 13, by 27 Aug., 1955. (T 709)

CENTRAL ELECTRICITY AUTHORITY
Southern Division

APPLICATIONS are invited for the following posts:

THIRD ASSISTANT ENGINEERS (OVERHEAD LINES) TRANSMISSION DEPARTMENT
S/13.698

Applicants should have experience of the design and construction of steel tower overhead lines of 132 kV, and experience of 275 kV work will be an advantage. Experience of checking contractors' drawings and supervision of contractors' work and diary sheets is desirable. Candidates should be corporate members of an appropriate professional institution, or hold qualifications leading to such membership.

Salary: N.J.B., AX/CX, Grade 4, £750/£925.

ELECTRICAL MAINTENANCE ENGINEER AND MECHANICAL MAINTENANCE ENGINEER PORTSMOUTH GENERATING STATION
S/13.699
S/13.700

Applicants should have had considerable experience in the maintenance of generating station, electrical/mechanical plant, and must be capable of controlling staff, and planning and supervising electrical/mechanical plant maintenance. Candidates should be corporate members of an appropriate professional institution, or hold qualifications leading to such membership.

Salaries: N.J.B., Grade G7, £790/£850.

Special application forms for each post, obtainable from P. D. A. Oliver, Divisional Secretary, 111 High St, Portsmouth, should be returned by 17 Aug. Please quote reference E.T.
27 July, 1955. (T 704)

MERSEYSIDE AND NORTH WALES ELECTRICITY BOARD

APPLICATIONS are invited for the appointment of DISTRICT MANAGER in the Southport District of the Board's No. 1 Sub-Area.

Salary, in accordance with N.J.M. Scale 2 (£1,400/£1,550 per annum) will be provisional and subject to confirmation by the appropriate negotiating body. The appointment is superannuable and subject to medical examination.

Application forms may be obtained from the Establishments Officer, Electricity House, Love Lane, Liverpool 3, and should be returned in sealed envelopes endorsed "District Manager," addressed to the Secretary of the Board at the same address. Closing date: 27 Aug., 1955. M. M. PARKER,
Secretary.
(T 712)

CENTRAL ELECTRICITY AUTHORITY
South Eastern Division

FIRST ASSISTANT STATION CHEMIST—Littlebrook Power Station. Applicants should preferably possess B.SC. Degree or equivalent qualification and have had experience in fuel testing, water analysis and lubricating oil testing. Experience of modern Power Station installations an advantage. Class L, Grade 9, £900/£975 per annum plus London allowance. Applications giving details of education, present position, experience, etc., should be sent to Station Superintendent, Littlebrook Power Station, Nr. Dartford, Kent, to arrive by 13 Aug. (T 685)

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD
Aberdeen Area

APPLICATIONS are invited for a vacancy for an INSTALLATION ENGINEER, N.J.B. salary and conditions, grading F/12 (£555 x £15—£600) and written application should be sent before 13 Aug. on a form obtainable from the undersigned.

The successful candidate will be required to inspect and test all types of installations, and to advise consumers.

Applicants must have a good knowledge of installation practice, be able to conduct interviews and deal with correspondence, and have suitable technical qualifications.
Millburn St, J. E. WHITTAKER,
Aberdeen. Area Manager.
29 July, 1955. (T 730)

A COMPANY with offices in Central London required for their Export Department a SALES ENGINEER, preferably having experience with electric motors, control gear, switchgear, to deal with estimates, tenders, overseas correspondence; please write—Box No. 4725, Electrical Times. (T 729)

A COMPANY engaged upon interesting and varied electrical projects in U.K. and overseas requires the services of experienced ELECTRICAL LAYOUT DRAUGHTSMEN. The positions offer scope for advancement and opportunities to have merit appreciated—Pension Scheme—Write in confidence to The Secretary, George E. Taylor and Co. (London) Ltd., 34 Southwark Bridge Rd, London, S.E.1. (T 659)

APPLICATIONS are invited by a firm in the North-West for the position of a TRANSFORMER DESIGN ENGINEER. The work covers all types of distribution and medium power units. Applicants should hold a University Degree or H.N.C. in electrical engineering. A sound engineering training is essential for the position, which holds good prospects. Salary depending on experience, in the order of £1,000 to £1,100 per annum. Full particulars, age, etc.—Box No. 4695, Electrical Times. (T 598)

ASSISTANT ENGINEER required for Overhead Line Contracts, Inverness Area. Good salary plus subsistence if applicable. Apply: B. French Limited, Pike Mills, Green St, Kidderminster. (T 596)

ASSISTANT ENGINEER / SURVEYOR required in connection with overhead line work in East Scotland. Applicants should have experience in this type of work and preferably be under 40 years of age. Applications giving details of training, experience and age to Employment Manager, Messrs Johnson and Phillips Ltd., Victoria Works, Charlton, S.E.7. (T 694)

ASSISTANT WORKS MANAGER required for new factory at Crawley, Sussex, engaged on Transformer manufacture up to 100 kVA and light electrical control equipment. Essentially a good disciplinarian. House available if required. A progressive situation offering good scope for a keen person. Full details to—Box No. 4693, Electrical Times. (T 597)

ASSISTANT TO WORKS DIRECTOR. A large engineering organisation desire to appoint an Assistant to the Works Director. Candidates should not be older than 38 and must have a good engineering background in addition to qualifications for administration at high level. The position will give a deep insight into a wide range of operations and will provide opportunities for a subsequent general managerial appointment. Superannuation Scheme. Applications in full detail to—Box No. 4719, Electrical Times. (T 697)

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DETAILED DRAUGHTSMAN, Senior or intermediate, for design work associated with commercial vehicle electrical equipment. Education up to O.N.C. level. Please apply Personnel Manager, Simms Motor Units Ltd., Oak Lane, East Finchley, N.2. (T 726)

CHEMICAL ENGINEER for Electricity Supply Undertaking in Baghdad. Applications are invited from suitably qualified engineers who have had experience and possess a thorough knowledge of feed water treatment for steam power stations and instruments related thereto. Should be able to carry out Boiler House Chemistry. Age limit 35. Salary £1,400/£1,600 per annum, plus high cost of living. Free house and heavy furniture. Three-year contract renewable, with first class passage each way for successful applicant and family (if married). Three months' leave in U.K. on completion of 24 consecutive months in Iraq.—Box No. 4691, Electrical Times. (T 594)

CHIEF PRODUCTION ENGINEER. A Chief Production Engineer is required by a leading electric lamp manufacturer. Extensive experience of electric lamp or valve manufacture would be advantageous, but a first-class production engineer with wider experience would be considered. The position involves responsibility for all departments of production engineering including special machine design. Prospects are excellent and an appropriate salary will be paid to a man with outstanding qualifications. The position is fully superannuated. Applications in full details to—Box No. 4721, Electrical Times. (T 698)

CLERK OF WORKS required in Regional Engineer's Department. Applicants should have served a recognised engineering apprenticeship and have had subsequent site experience on mechanical, heating and ventilating or electrical installations. They must be able to supervise site installations from specifications and drawings. Salary scale £580 x £20 (3) x £25 (2)—£690.

Apply, giving age and full details of experience with names of two referees to Secretary, North West Metropolitan Regional Hospital Board, 11a Portland Place, W.1, by 18 Aug. (T 720)

DESIGNER required with experience of Distribution and Medium Power Transformers up to 5,000 kVA, 33 kV or over. Permanent and progressive position. Salary commensurate with experience and qualifications. Apply, in confidence, to Chief Engineer, Transformers (Watford) Ltd., Sandown Road, Watford, Herts. (T 693)

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ELECTRICAL ASSISTANT required by firm of Consulting Engineers for work on lighting and power installations for all classes of buildings. Applicants should have practical experience and should be capable of preparing specifications under supervision. Qualifications O.N.C. minimum. Write, stating qualifications, experience, age and salary required, to J. Roger Preston and Partners, 15 North Audley St, London, W.1. (T 668)

EXPERIMENTAL OFFICER required by the Research Laboratory of British Insulated Callender's Cables Ltd., at Shepherds Bush, for the design and construction of experimental apparatus. Applicant should have a good knowledge and experience of electronic equipment. Pension Fund. Five-day week. Applications should be made, giving details of qualifications, experience and salary required to Staff Officer, British Insulated Callender's Cables Ltd., 21 Bloomsbury St, London, W.C.1, quoting reference L/4/55. (T 695)

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ELECTRICIAN'S MATE (Telephone) required by London Electricity Board in Chief Engineer's Operations Branch at Chelsea, S.W.3. N.J.I.C. rates and conditions. 3s. 9½d. per hour. Application forms from Personnel Officer, 46/7 New Broad St, London, E.C.2. Please enclose addressed envelope and quote ref.: M/4113/T. (T 696)

ELECTRICAL ENGINEERING DRAUGHTSMEN required by a firm of Engineers and Contractors on Tees-side for complete electrical installation, design, including motor application, control scheme engineering, distribution and cabling. Experience of contract work and estimating an advantage. Apply stating age, experience and salary required, quoting reference "W," to —Box No. 4609, Electrical Times. (T 281)

ELECTRICAL ENGINEER or PHYSICIST required for position at High Voltage Laboratory.

The Laboratory at present under construction is nearing completion. It is to be equipped with a 2,500 kV impulse generator and power frequency transformers to give 1,300 kV, together with the necessary ancillary apparatus.

The principal purpose of the Laboratory is to carry out research and development work on different types of high voltage glass insulators. Some outside work may, however, be accepted.

Candidates should possess a degree in Electrical Engineering or Physics and have had experience in High Voltage Laboratories.

Applications should give details of age, training and experience, and be addressed to The Personnel Officer (Staff), Pilkington Brothers Limited, St. Helens, Lancashire. (T 678)

BRITISH STANDARDS INSTITUTION

ELECTRICAL ENGINEERS are required by the British Standards Institution for work in connection with the approval of all types of electrical equipment for export to Canada. Applicants should have served an apprenticeship and have technical qualifications equivalent to graduate membership of I.E.E.: preference will be given to corporate members.

The positions are pensionable and the salary will be in accordance with qualifications and experience. *Apply*:

Establishment Officer,
British Standards Institution,
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ELECTRICAL ENGINEERS required by large firm of Consulting Engineers. Candidates must be up to O.N.C. standard and preferably H.N.C. Permanent post, staff pension scheme. Please reply giving details of previous experience to: Box 223, Glovers Advertising, 351 Oxford St, London, W.1. (T 556)

ELECTRICAL ENGINEER required for Sales Department of Company, West London area, to handle automatic control gear schemes. H.N.C. or equivalent, and ability to handle technical correspondence. Pension Scheme. Commencing salary £700/£800 according to experience.—Box No. 4677, Electrical Times. (T 533)

ELECTRICAL MOTOR DESIGNER required by centrifugal pump manufacturers. Must be experienced in the design and development of medium-sized A.C. and D.C. machines, submersible-type motors, etc. Excellent opportunity for qualified, enthusiastic and practical man to improve established and internationally-known machines, and to introduce new ideas. The post is one of responsibility and salary will be in accordance. Please send full details including age, qualifications, experience and suggested salary to the Box Number quoted below. Applicants may be assured that their replies will be treated as fully confidential. —Box No. 4713, Electrical Times. (T 651)

ESTIMATING STAFF required. Male or Female. Write stating age, experience and salary required to the Cable Makers Association, 53/54 High Holborn, London, W.C.1. (T 677)

ENGINEER DRAUGHTSMAN, Junior, required by Electrical Contractors in Westminster Area, with some knowledge of Electric Lighting and Power Installations. Write stating age, experience and salary required, to—Box No. 4709, Electrical Times. (T 647)

IMPERIAL CHEMICAL INDUSTRIES LIMITED, Metals Division, require an ELECTRICAL MAINTENANCE ENGINEER for their works in South Wales. Candidates should have a Higher National Certificate or equivalent. Experience with modern Rolling Mill Electrical Equipment, electrical furnaces, instruments and ancillary plant in connection with production of non-ferrous metal is desirable. The position is permanent and pensionable and qualifies for inclusion in the Company's Profit Sharing Scheme. Removal expenses will be refunded and, in approved cases, financial assistance will be given towards house purchase. Application forms may be obtained from Division Staff Manager, Kynoch Works, Witton, Birmingham 6, quoting ENG/246. (T 676)

INDUSTRIAL HEATING ENGINEERS—Vacancies exist on the staff of The General Electric Co., Ltd., at the Head Office of their Sales Organisation in Kingsway. Applicants, not over 35 years of age, should have had previous sales experience and be familiar with the preparation of I.H. schemes. Apply in writing, quoting ref. I.H., to the Staff Manager, Magnet House, Kingsway, W.C.2. (T 645)

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Applications, with details of experience to Spear's Electric Ltd., Walnut Tree Close, Guildford. (T 721)

Box No. replies to be addressed to the ELECTRICAL TIMES, Sardinia House, Sardinia Street, London, W.C.2

LABORATORY ASSISTANT required by Simms Motor Units Ltd., Oak Lane, Finchley, N.2, for the research and development of electronic and electro-mechanical mechanisms associated with the commercial vehicle industry. H.N.C. or equivalent standard. Apply by letter stating age, qualifications and experience to Personnel Manager. (T 725)

LANCASHIRE DYNAMO AND CRYPTO Ltd., Manchester, have vacancies for A.C. or D.C. DESIGNERS and invite applications for posts carrying good prospects. All candidates will be interviewed at their convenience and expenses paid. Replies stating age, experience, etc., should be sent to the General Manager, Lancashire Dynamo and Crypto Ltd., Trafford Park, Manchester 17. (T 602)

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Three-year contract, renewable, with first class passage each way for successful applicant and family (if married). Three months' leave on full pay in U.K. on completion of 24 consecutive months in Iraq, first class leave passages being paid.—Box No. 4689, Electrical Times. (T 593)

TECHNICAL DESIGNER and DESIGNER DRAUGHTSMAN required with knowledge of production of light to medium electro and mechanical products. Please reply stating full particulars, experience, age and salary required, to S.E.I. Ltd., Times Mill, Heywood, Lancs. (T 724)

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TRANSFORMER ESTIMATOR AND TECHNICAL CORRESPONDENT. Johnson and Phillips Ltd. have a vacancy for an estimator and technical correspondent in their Transformer Department. The post is of a senior nature and applications are invited from men with experience in the preparation of tenders for both home and overseas markets for all classes of transformers. Applications giving particulars of training and experience together with salary required to Employment Manager, Johnson and Phillips Ltd., Victoria Way, Charlton, London, S.E.7. (T 526)

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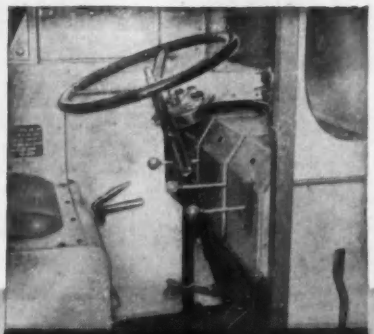

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ESTD. 1912

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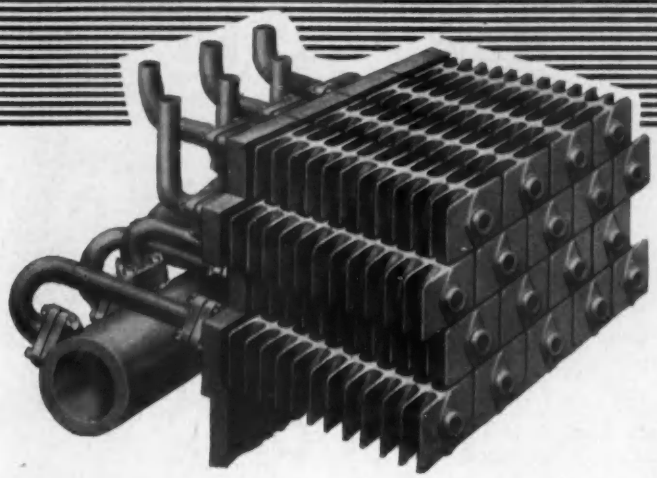

Greens of Wakefield specialise in the design and manufacture of Economisers, of which they were the original inventors, and have the longest experience. Greens make Economisers of all types, for all pressures. The section illustrated is the Premier Diamond Steel Tube Economiser for highest pressures, with cast-iron gilled sleeves shrunk on steel tubes arranged in shallow tiers. This design combines the advantages of extended heating surface in compact dimensions, controlled gas flow and the most complete facility for inspection and cleaning. Also available with welded joints.

You should specify a Green's Economiser—

and that's why!

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E. GREEN & SON LTD · WAKEFIELD

Makers of economisers for more than one hundred years

GE 130

Now Available

the NEW wallchart based on the

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METHOD

of treatment for apparent death from

ELECTRIC SHOCK

Instructions prepared by

Dr. P. Pringle, LL.B., B.Sc. (Econ.), M.R.C.S., L.R.C.P., D.I.H.

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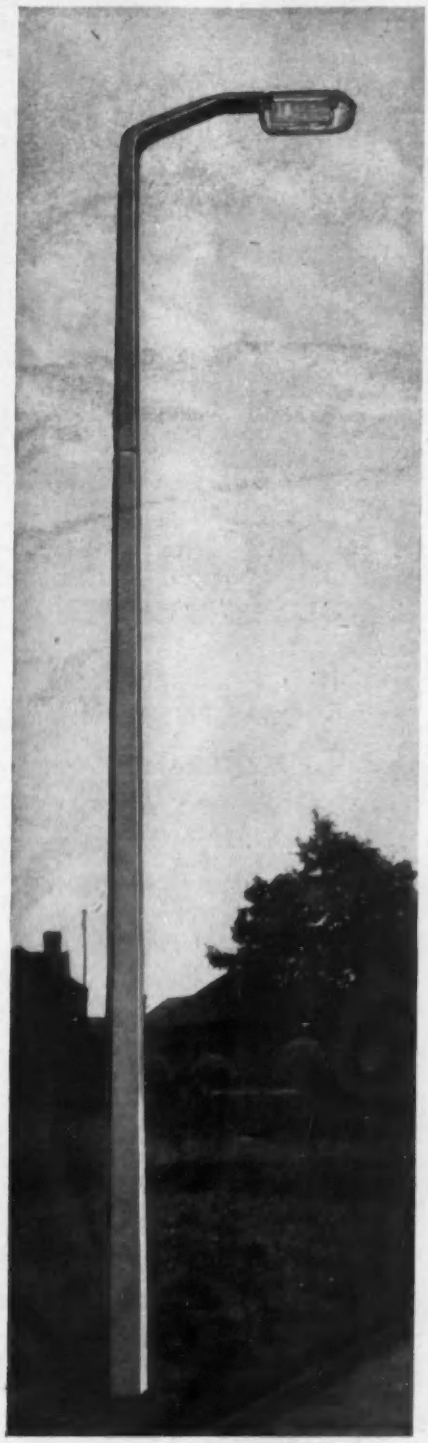


"Epic" spun artificial stone column to B.S. Specification. For Group "A" roads. Approved by the Council of Industrial Design.

STREET LIGHTING

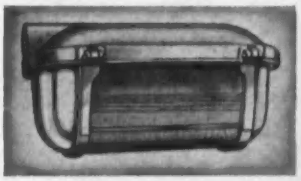
Columns & Fittings by REVO REGD.

For close on half a century, the name Revo has been associated with the best in street lighting and the selection shown on this page is merely representative of the wide range in current production.

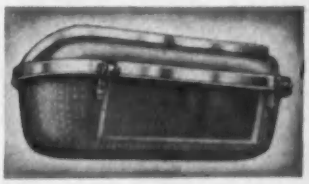
The Company's Technical Staff will be pleased to advise on all aspects of Public Lighting and the Revo Street Lighting Erection Department is available for the installation of equipment.

Details and catalogues will gladly be sent to interested authorities who are invited to forward their inquiries without obligation.

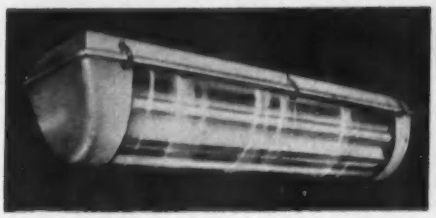
C13594 "Silverblue" street lighting fitting for use with mercury vapour discharge lamps. Available for top or side entry mounting. Group "A" roads.



C13723 "Silvergold" street lighting fitting for use with sodium vapour discharge lamps. Group "A" roads.



"Sol-Etern" street lighting fitting for use with 2, 3 or 4 —5 ft. fluorescent lamps. Group "A" roads.



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Telephone : Tipton 1891 Telegrams : Revo, Tipton

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Makers of Electric Cookers, Domestic Appliances, Public and Industrial Lighting, Switchgear, Fans

FAIR PLAY

SWITCH BLOCKS
built of KILN DRIED *timber*
STAY FLAT
AND CORRECT SHAPE

We invite your enquiries

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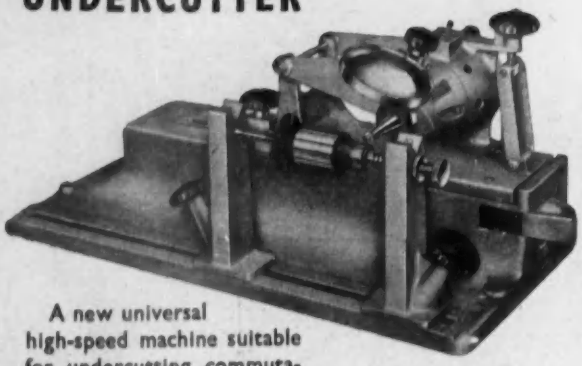
MARTINDALE

BENCH TYPE
UNDERCUTTER



A new universal high-speed machine suitable for undercutting commutators of any size up to 6" diameter with armatures up to 10" diameter.

It is the simplest and most efficient machine so far designed for this work.

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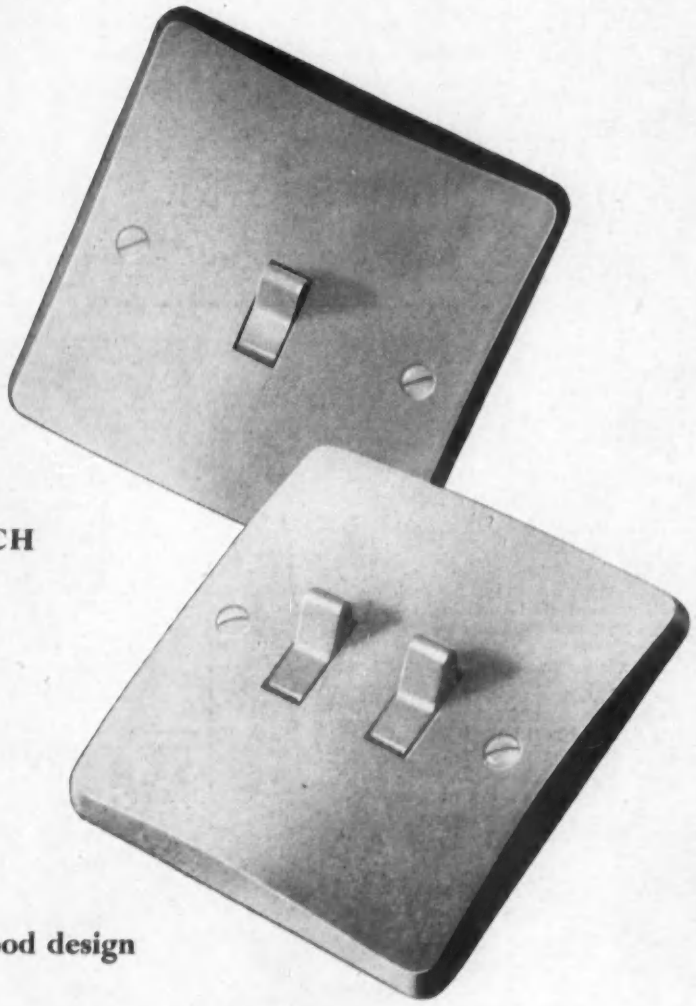

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LOW VOLTAGE LIGHTING TRANSFORMER
In die-cast Aluminium Case, Self-isolating fitted with D.P. on-off Switch and H.R.C. Fuses. To B.S.S. 794/38. Can be supplied with 1, 2 or 3 arm Lighting Brackets or Low Voltage Plugs and Sockets.

NEW MEDIUM VOLTAGE ALL INSULATED TEST LAMP IN MOULDED RUBBER
100—500 Volts. A.C. D.C. Fitted with H.R.C. Fuses in each prod.

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For portable m/c tools, handlamps, etc., Secondary Voltages from 12 V — 110 Volts. Capacities from 50 V.A. to 750 V.A.

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For testing earth fault loop resistance.

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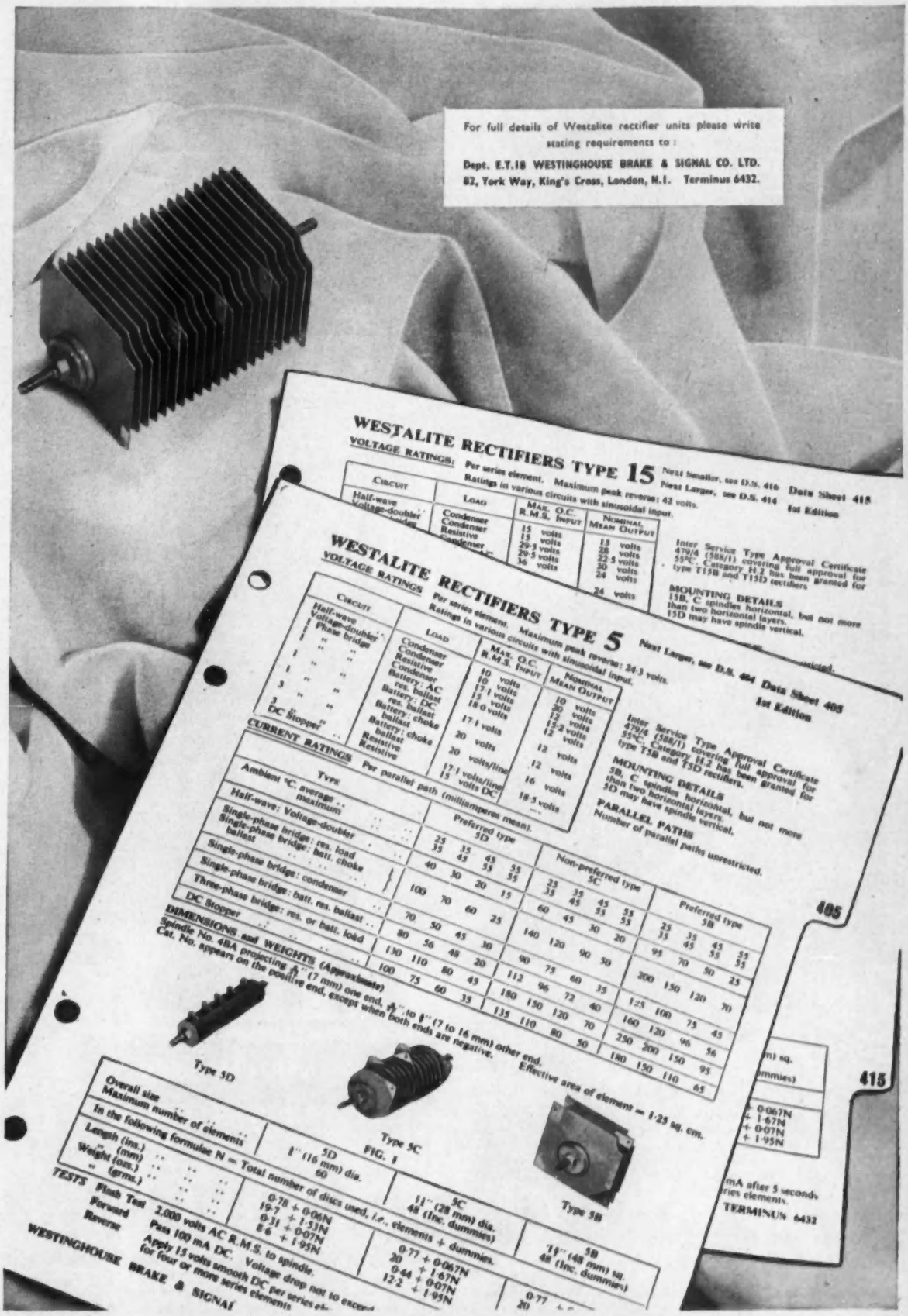


For full details of Westalite rectifier units please write stating requirements to :

Dept. E.T.18 WESTINGHOUSE BRAKE & SIGNAL CO. LTD.
82, York Way, King's Cross, London, N.1. Terminus 6432.

WESTALITE RECTIFIERS TYPE 15

Next Smaller, see D.S. 416 Next Larger, see D.S. 414 Data Sheet 415 1st Edition

VOLTAGE RATINGS: Per series element. Maximum peak reverse: 42 volts.
Ratings in various circuits with sinusoidal input.

Circuit	Load	Max. D.C. R.M.S. Input	Nominal Mean Output
Half-wave	Condenser	15 volts	13 volts
Voltage-doubler	Condenser	15 volts	28 volts
	Resistive	29·2 volts	22·5 volts
	Condenser	29·5 volts	30 volts
		36 volts	24 volts
			24 volts

Inter Service Type Approval Certificate 479/6 (588/1) covering full approval for 55°C. Category H.2 has been granted for type T15B and T15D rectifiers

MOUNTING DETAILS
15B, C spindles horizontal, but not more than two horizontal layers.
15D may have spindle vertical.

WESTALITE RECTIFIERS TYPE 5

Next Larger, see D.S. 404 Data Sheet 405 1st Edition

VOLTAGE RATINGS Per series element. Maximum peak reverse: 24·3 volts.
Ratings in various circuits with sinusoidal input.

Circuit	Load	Max. D.C. R.M.S. Input	Nominal Mean Output
Half-wave	Condenser	10 volts	10 volts
Voltage-doubler	Condenser	10 volts	20 volts
1 Phase bridge	Resistive	17·1 volts	12 volts
1 " "	Condenser	17·1 volts	15·2 volts
1 " "	Battery: AC res. ballast	18·0 volts	12 volts
1 " "	Battery: DC res. ballast	17·1 volts	12 volts
3 " "	Battery: choke ballast	20 volts	12 volts
3 " "	Battery: choke ballast	20 volts	12 volts
DC Stopper	Resistive	17·1 volts/line	16 volts
	Resistive	15 volts DC	18·5 volts

CURRENT RATINGS Per parallel path. (milliamperes mean).

Type	Preferred type 5D				Non-preferred type 5C				Preferred type 5B			
Ambient °C. average ..	25	35	45	55	25	35	45	55	25	35	45	55
maximum ..	35	45	55	55	35	45	55	55	35	45	55	55
Half-wave: Voltage-doubler ..	40	30	20	15	60	45	30	20	95	70	50	25
Single-phase bridge: res. load ..	100	70	60	25	140	120	90	50	200	150	120	70
Single-phase bridge: batt. choke ballast ..	70	50	45	30	90	75	60	35	125	100	75	45
Single-phase bridge: condenser ..	80	56	48	20	112	96	72	40	160	120	96	56
Three-phase bridge: batt. res. ballast ..	130	110	80	45	180	150	120	70	250	200	150	95
DC Stopper ..	100	75	60	35	135	110	80	50	180	150	110	65

DIMENSIONS and WEIGHTS (Approximate)

	5D	5C	5B
Overall size ..	1" (116 mm) dia.	11" (278 mm) dia.	11" (48 mm) sq.
Maximum number of elements ..	60	48 (inc. dummies)	48 (inc. dummies)
In the following formulae N = Total number of discs used, *i.e.*, elements + dummies.			
Length (ins.) ..	0·78 + 0·06N	0·77 + 0·067N	0·77 + 0·067N
" (mm) ..	19·7 + 1·53N	20 + 1·67N	20 + 1·67N
Weight (ozs.) ..	0·31 + 0·07N	0·44 + 0·07N	0·44 + 0·07N
" (grms.) ..	8·6 + 1·95N	12·2 + 1·95N	12·2 + 1·95N

Spindle No. 4BA projecting ¼" (7 mm) one end, ¼" to ⅜" (7 to 16 mm) other end.
Cat. No. appears on the positive end, except when both ends are negative. Effective area of element = 1·25 sq. cm.

Type 5D

Type 5C FIG. 1

Type 5B

TESTS Flash Test 2,000 volts AC R.M.S. to spindle.
Forward Pass 100 mA DC. Voltage drop not to exceed
Reverse Apply 15 volts smooth DC per series element
for four or more series elements

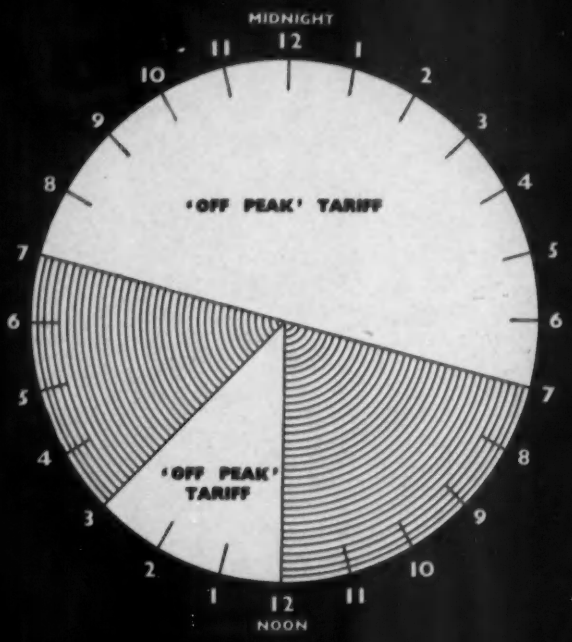
WESTINGHOUSE BRAKE & SIGNAL

405

415

...mA after 5 seconds
...ries elements.
TERMINUS 6432

reduce electricity costs...



switch to 'OFF PEAK' TARIFF AUTOMATICALLY with

VENNER TIME SWITCHES

In the constant search for reduced costs the 'off peak' period offers opportunity for the use of electricity at low rates. VENNER Time Switches are available for the automatic control of restricted hours supply which conform with all the requirements of the Electricity Boards.

Write for leaflet ET/5.

Illustrated is one of the ERB range of Time Switches which has a synchronous drive with 36 hour spring reserve and will operate automatically at various switching times including week-end shut down.

VENNER LIMITED · KINGSTON BY-PASS · NEW MALDEN · SURREY Tel: MALDEN 2442 (7 lines)

Associated Companies: Venner Accumulators Ltd., Venner Electronics Ltd.

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Six star points have quickly won for the Parnall Washer that jackpot of salesmanship—USER RECOMMENDATION.

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No other washer compares in elegance with the Parnall, and women are deeply influenced by design in their choice of domestic appliances.

3 EFFICIENCY
The unique Parnall agitator provides a scientific water-action that *really* gets clothes cleaner.

5 RELIABILITY
In addition to carrying the seal of the Good Housekeeping Institute the Parnall has our own twelve months' guarantee, most generously interpreted: plus nation-wide service organization.

2 QUALITY CONSTRUCTION
Your own specialized knowledge will approve the fine engineering that lies behind the Parnall's superb appearance.

4 EASE OF OPERATION
Standard sink height obviates stooping. Power washing, wringing and emptying mean less exertion.

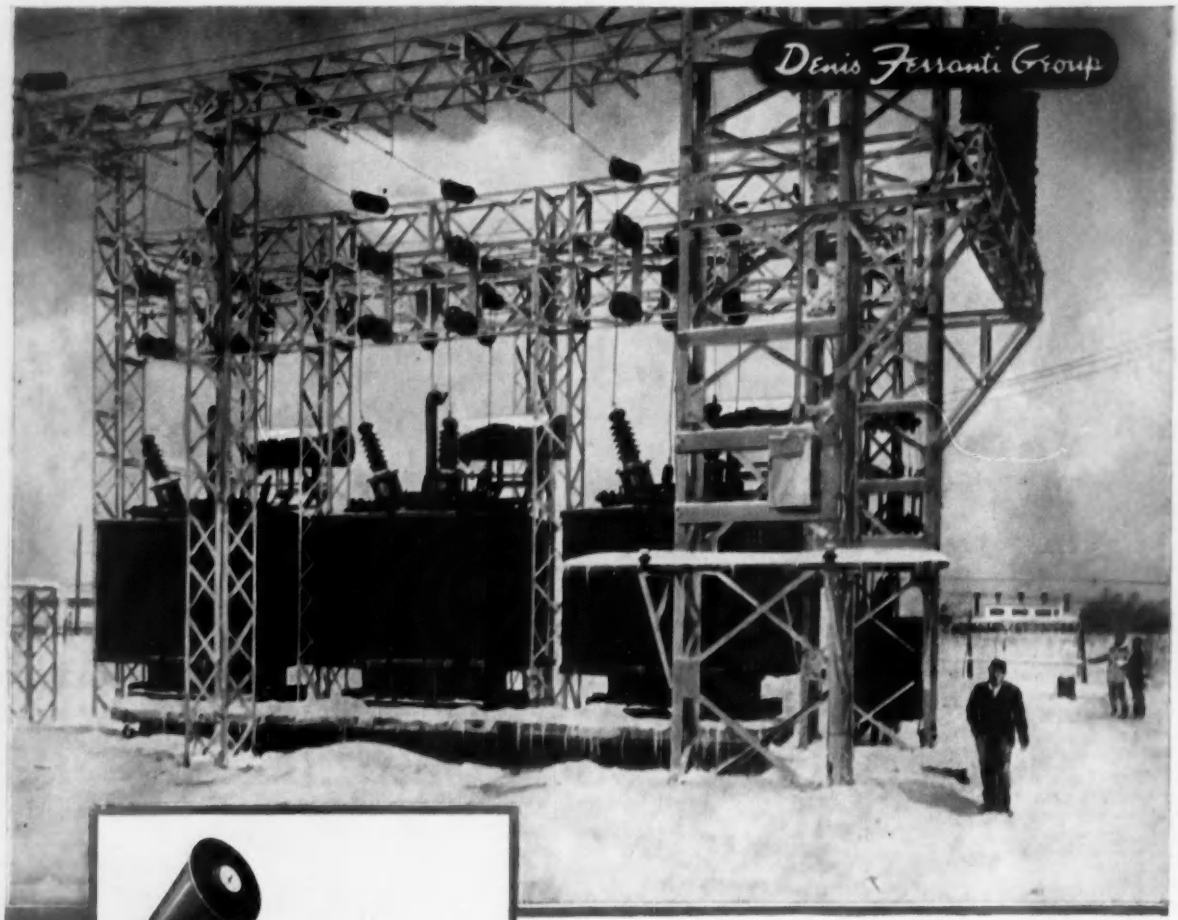
6 PRICES:
Such value for money at £65.2.0 (or £75.12.0 with own heating element)—no wonder Mrs. Brown is selling for you! Wherever there's a Parnall User, she's busy telling her friends to buy one.

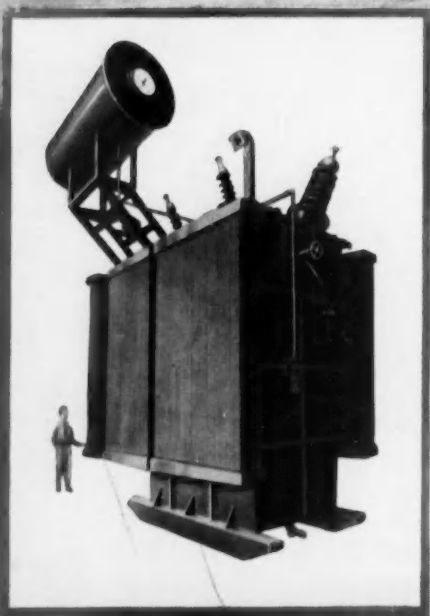
P.S *And don't forget that the Parnall is supported by* consistent *nation-wide advertising, displays, showcards, leaflets and demonstrations at Exhibitions — with enquiries passed to YOU!*

PARNALL World's Best Safety Washer!

PARNALL (YATE) LIMITED · 255 NORTH CIRCULAR ROAD · NEASDEN · NW10

WHG/P30





POWER TRANSFORMERS

DENIS FERRANTI TRANSFORMERS INSTALLED AT CANADIAN ARSENAL VALCARTIER QUEBEC.

QUALITY DELIVERY

The illustration shows 3 Denis Ferranti 69 kV single-phase 60 cycle transformers forming a 10,000 KVA 3-phase bank supplied to the Eastern Electric Supply Co and installed at a Canadian Arsenal. Inset shows one of these transformers.

TRANSFORMERS ARE BUILT IN ALL SIZES UP TO 30 MVA.

DENIS FERRANTI CO. LTD.

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